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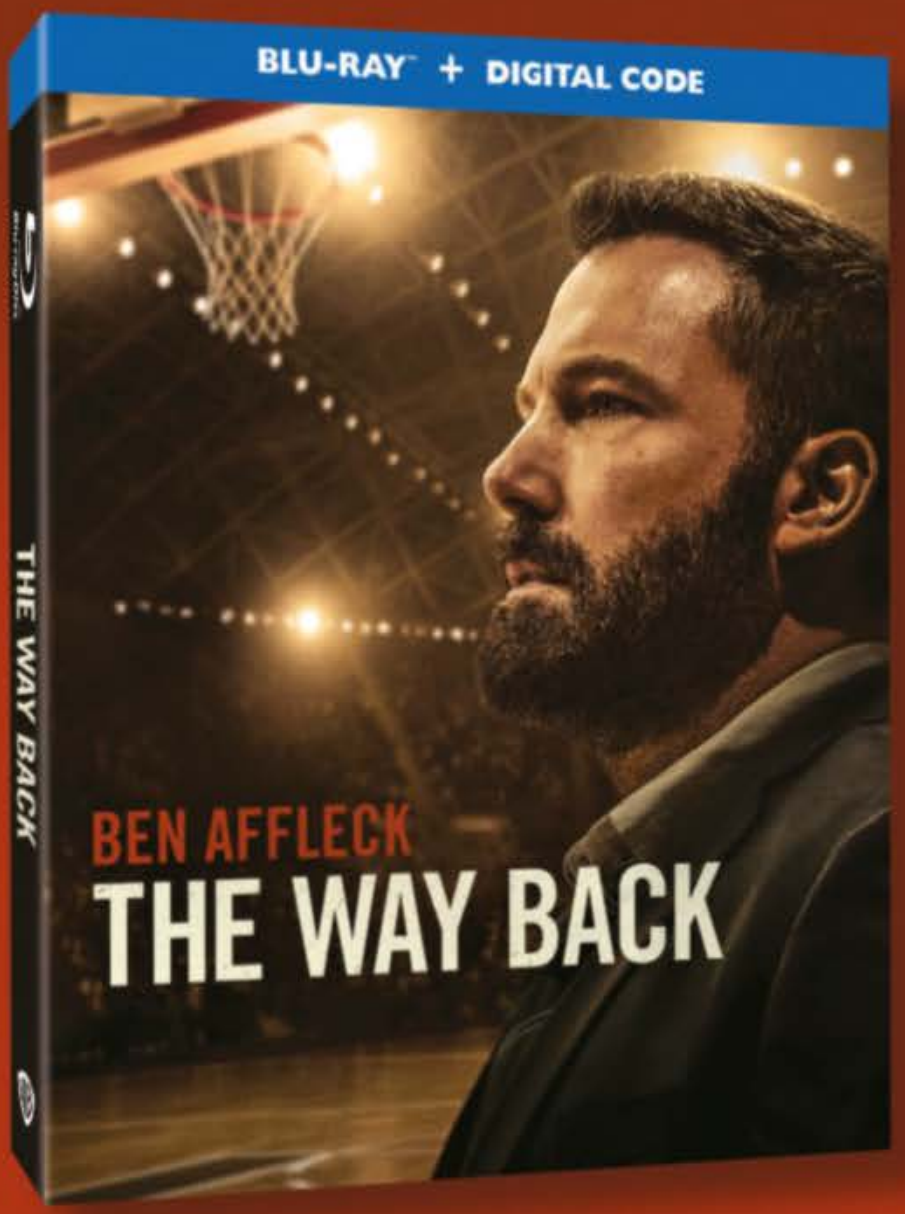

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Zak Storey

IN A TIME OF WAR

THIS IS THE SECOND TIME I've written this intro. In fact, I'd drafted my first version two days before I even started my job. I was, and still am, unbelievably excited to take on this role. Becoming editor of *Maximum PC* is a dream come true. This is home to me. I owe everything to this magazine and its community. To all of you. When I heard that Alan Dexter, my predecessor and all-time favorite boss, was leaving the publication, I knew I had to throw my hat in the ring. After all, having the chance to lead this brand into the next decade is a once-in-a-lifetime opportunity. It's funny how much the world can change in just 14 days.

Undoubtedly, the COVID-19 pandemic is one of the biggest catastrophes we have faced in the last 50 years. Its potential reach and impact is incalculable. Once the quarantines lift, and we can hug our families again, I've no doubt everything will look very different. Yet, as economies grind to a halt and purchasing power falls, companies are looking to mitigate the impact in any way they can. Our own publishing house is no different, and the lengths to which it has gone to help keep the majority of us employed here are admirable. Sadly, however, this beloved publication of ours hasn't escaped the cutbacks.

You'll notice that the mag itself is skinnier this issue. We've lost 12 pages. This was something thrust upon us in the last weeks of production. As an editor, working on his first issue, it's not something you want to have to tell your readers, but sadly I have no choice. Let me assure you, this is only temporary, this is not the "new normal." Once the crisis subsides, and it will subside, I will fight tooth and nail to get those 12 pages back, and more, because you deserve that. You've supported us throughout these many years, and I hope you'll stick with us in these dark days, too. Community is more important than ever, It's vital that we stick together and support each other in these times. I know it's not the same as our old forums, but if you have any questions, or just need someone to talk to or game with, you can find myself and some of the other *Maximum PC* team here on Discord: https://bit.ly/MPCDiscord.

Anyway, enough of that! What's in this issue? Well, first we're taking a deep dive back into the world of liquid cooling, and we've also expanded our "Build It" section for this issue, and beyond, to give you all the tips and tricks you need to build your next liquid-cooled monster. We've also compiled a list of some of the best free software out there to boost your working-from-home productivity. Combine that with a bevy of kick-ass tutorials and reviews, and I really do hope you enjoy this issue.

Please do stay safe, stay healthy, and I look forward to hearing from all of you. Until next time.

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Console War Beckons

And we have the technical specifications to start it

MICROSOFT AND SONY have been tantalizing us with snippets about their new consoles for months, and now we have the rough technical specs. Microsoft's Xbox Series X has custom AMD silicon comprising of an eight-core Zen 2 processor running at 3.8GHz; it has multithreading, but enabling this will drop the clock to 3.6GHz. Graphics are supplied by an RDNA 2 chip with 52 compute units (3,328 cores), running at 1,825MHz, complete with hardware ray tracing. Microsoft boasts of 12 teraflops of graphical processing power on tap. In theory, the new Xbox has about four times the muscle of an Xbox One S. You also get 16GB of GDDR6, 10GB of which is reserved for the GPU, and 2.5GB for the OS. Storage is a custom 1TB SSD. The target is 4K at 60fps, but it can go well beyond that, to 8K and 120fps.

Sony's PlayStation 5 follows a similar pattern. Again, it's an eight-core, 16-thread Zen 2, clocked at a maximum of 3.5GHz with multithreading enabled. The graphics are supplied by an RDNA 2 GPU with 36 compute units, clocked at 2,230MHz. This is high for an AMD GPU—some tinkering has been done. It also has hardware ray tracing. Memory is 16GB of GDDR6; with an 825GB SSD. PCIe 4.0 and other trickery push the storage bandwidth to 5.5GB/s, about twice the Xbox's 2.4GB/s.

Sony has taken a different approach to boost. While the Xbox is locked to two speeds, the PS5 is more flexible, depending on load and temperature. Sony has made use of AMD's work on adaptive voltages and frequencies it developed for mobile chips, and claims that having fewer compute units in the GPU, but running faster, is more efficient. The PS5 manages 10.3 teraflops of number crunching. The PS5 also has a intriguing 3D audio chip—it uses HRTF profiles (Head Related Transfer Function) to give the illusion that sounds are coming from all around. Initially, this is limited to headphones, but it is hoped to expand this to cover all speakers. Both machines have 4K UHD Blu-ray drives, probably the last time we'll see optical drives on a console.

These machines are, in essence, PC gaming rigs in custom boxes. Originally, consoles borrowed hardware from arcade games. 1999's Sega Dreamcast, changed all that, using standard PC chips. The original Xbox used a Pentium III, although hardly super-speedy, even by the standards of the day. Since then, every generation of console has moved closer to PC standards, and moved upmarket. These two equate to the top part of the mid-range—pretty tasty. Both manufacturers are keen to point out that their consoles will offer backward compatibility. The Xbox Series X will run Xbox One games directly, plus Xbox and Xbox 360 games under emulation. The PlayStation 5 will play PS4 and PS4 Pro games in "legacy mode."

The new consoles will be available for the holidays, which generally equates to November, but prices are yet to be confirmed. The previous generation was $399 for the PS4, and $499 for the Xbox; that hundred bucks difference did Sony a lot of good at the time. That was seven years ago, and both machines are carrying a lot of expensive silicon. The PS5 looks likely to be $499; the Xbox won't be much different. Either manufacturer might try to undercut the other, but margins are going to be too tight for much maneuvering.

Posturing on who has the best hardware is not the issue—it's too close to call. Who has the best games is more relevant. Even that's a tough one; porting a PC game to either system is relatively easy. This leaves us with exclusive games and the quality of online gaming. It looks as if we have two evenly matched contenders. At least this will sharpen up the competition, and leave Sony and Microsoft scrabbling for something to give them the edge. Which is good news for us—decent hardware and a keen rivalry. **–CL**

Microsoft has gone for a block monolith look, bordering on dull.

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> "These machines are, in essence, PC gaming rigs in custom boxes.

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AMD MOBILES GO ZEN 2

Renoir brings healthy performance jump

AMD'S MOBILE CHIPS have generally taken second place to its desktop versions. No longer: AMD claims to have been working on "Renoir" since 2017, optimizing it for mobile work. The result is a carefully packaged chiplet design with up to eight 7nm Zen 2 cores and Vega-based graphics. Finally, AMD's mobile chips have the latest silicon, with the attendant jump in IPC. A significant improvement over the 3000-series, which is hardly sparkling.

There's the usual split: the U range for low-power work, with a TDP of 15W, and the beefier H and HS series, with a TDP of 35 or 45W. The initial range of nine starts with the Ryzen 3 4300U, with four cores and four threads, running at a base of 2.7GHz. Then there are three six-core Ryzen 5s: the 4500U has six threads; the 4600U and 4600H get the full 12. The pattern is repeated with the three eight-core Ryzen 7 versions, the 4700U having eight threads, the 4800U and 4800H getting 16. At the top of the 4000 tree we have the eight-core Ryzen 9 4800H and HS. The 4800H has a base clock of 3.3GHz, with a boost of up to 4.4GHz; the HS clocks at 3.0 and 4.3GHz respectively. Both have eight Vega graphics cores running at 1,750MHz.

AMD's comparisons with an Intel Core i7-9750H show the 4800H beats it by 8–80 percent in a set of productivity benchmarks. It can give Intel's i9-9980H something to think about, too, just leaving the i9-9980HK out of reach.

AMD chips tend to be used in generic laptop designs, while the high end was designed around Intel's best—not helped by AMD's reputation for poor battery life, which it claims to have addressed. Intel's mobile parts are split between 10nm Ice Lake and 14nm Comet Lake, a choice of better GPU or CPU performance. AMD is about to give Intel the same headache it has given it in the desktop market. **–CL**

WIN 10 HITS A BILLION

ALTHOUGH WIN 7 STILL UNACCOUNTABLY POPULAR

IT IS NOTORIOUSLY DIFFICULT to get an accurate figure on how many people are using what OS, but Microsoft thinks that after five years, Win 10 is now running on one billion machines. Quite an achievement, but not what Microsoft had originally planned. It wanted to reach that target in 2017, but the free upgrade from Win 7 wasn't as popular as the company imagined. Win 10 was called the last version of Windows by Microsoft back in 2015, it has also been called the "forever version." Instead of new releases, we just have a continually updated version, including UI changes to keep things fresh.

However, there is still a lot of work to do yet. Despite the withdrawal of official support, Win 7 stubbornly refuses to fade away. There are an estimated 300,000 Win 7 systems—about a quarter of all PCs. Apparently, it is still rather popular in China. Even Steam still has a solid minority of Win 7 users—about 10 percent. As XP proved, it can take a long time for some people to move on. **–CL**.

STREAMING VR

Now you don't need a high-end rig

HIGH-END VR requires high-end hardware. Or it did. Cloud gaming company Shadow is running a streaming VR system called the VR Exploration Program, which we assume is a beta test. The initial test will only work using an Oculus Quest headset and a pretty zippy connection: 15ms response, 100Mb/s download, and 20Mb/s upload. The game streaming services run from $11.99 to $39.99 a month. Shadow's approach is different from Stadia—you can play your PC games on a multitude of devices, including smartphones, Macs, and any old PC. Your games actually run on a beefy Win 10 box in Shadow's data centers. Log on and add any games you own to your cloud box. Shadow doesn't sell you games; what you get is remote access to a high-end rig. VR is power-hungry and pricey; streaming it might lower the expensive initial hurdle. Could this approach finally move VR mainstream? We won't hold our breath. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

CALL OF DUTY: WARZONE
Activision's free battle royale game clocked up 30 million players in its first two weeks.

3D PRINTERS HELP OUT
Two Italian 3D printing companies have been producing valves for ventilation machines.

COMPUTER VS. COVID-19
The Department of Energy's Summit supercomputer is running simulations to test compounds for possible coronavirus inhibitors.

TRAGEDIES

SELF-DRIVING THEFT
Uber's acquisition of Primo self-driving tech is explained: The hire from Waymo had stolen it.

ALIEN LIFE NOT FOUND
The SETI project is to close after 21 years. It used distributed analysis of radio signals to search for alien life.

PC SALES SLUMP
It looks as if one victim of the coronavirus will be PC sales, which are predicted to fall by 30 percent or more.

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Jarred Walton

TECH TALK

Zen 3 Aims to Keep AMD CPU Momentum Rolling

OVER THE PAST SEVERAL YEARS, AMD's CPU team has been firing on all cylinders. Or cores.... It has pushed Intel in ways that were almost forgotten. And AMD is not letting up on the pressure, either. In its recent Financial Analyst Day briefings, AMD went into detail about its plans for the next several years of CPU and GPU advancements.

The most important bits: Yes, Zen 3 and fourth-gen Ryzen CPUs are coming and should launch before the end of the year. Plus, RDNA 2 and Navi 2x GPUs with ray-tracing capabilities will also arrive before 2021. I'm going to leave the GPU discussion for another day and focus on the Zen 3 CPUs.

First, Zen 3 will continue to use TSMC's 7nm FinFET manufacturing process. There were earlier rumors that it would switch to TSMC's N7+ Extreme Ultraviolet (EUV) node—and it still might—but AMD has stopped referring to it as "7nm+" and now just calls it 7nm. That doesn't mean it's the same node as Zen 2, however, as TSMC has a newer second-gen N7P "performance-enhanced" node available that sticks with Deep Ultraviolet (DUV).

N7P is design compatible with the original N7, but optimizations allow TSMC to deliver either 7 percent higher boost performance (clock speeds) at the same power, or keep the same performance and reduce power use by 10 percent. N7+ is not design compatible, but offers larger potential gains: It allows for 15–20 percent better density than N7, so more transistors can be crammed into a chip, or chips can be smaller. Whether it uses EUV N7+ or DUV N7P, Zen 3 should see at least modest improvements on the silicon side of things.

AMD will also be updating the base architecture, as it always does, but it hasn't revealed too many details. Most of what we know comes from the data center side of things, where the 7nm Zen 3 "Milan" CPUs will feature a modified Core Complex (CCX) compared to previous Zen architectures. The biggest change is that instead of having two four-core CCX partitions in a chiplet with 16MB of L3 cache each, Zen 3 will have a unified eight-core CCX with a shared 32MB L3 cache. That's important as it should improve latency and memory throughput, which improves performance.

> Zen 3 and fourth-gen Ryzen CPUs are coming and should launch by the end of the year.

Going back to the original Zen architecture, AMD's CCX has been both good and bad. Having a simplified building block that can be repeated as needed is great for scaling to higher core counts, and it reduces time to market and overall chip complexity. It's a major part of why AMD was able to launch eight-cores with first and second-gen Ryzen, then up to 16-cores with third-gen Ryzen. However, the partitioned L3 cache CCX approach does add latency to any cache accesses that have to cross from one CCX to the other. Zen 2 helped overcome this by doubling the L3 cache size, and Zen 3 will improve things further by unifying the L3 cache for each chiplet. There will still be added latency for cross-chiplet cache accesses, but the sheer size of the L3 caches will help to combat that.

AMD is taking a page out of Intel's abandoned tick-tock strategy.

There are also reports that Zen 3's floating point performance could be up to 50 percent higher than in Zen 2, with instruction per clock (IPC) gains from 8–17 percent, depending on workload.

This is all at the same power requirements as Zen 2. These chips are already easily beating Intel's best when it comes to performance per watt. It desperately needs something better than 14nm+++ CPUs if it hopes to compete.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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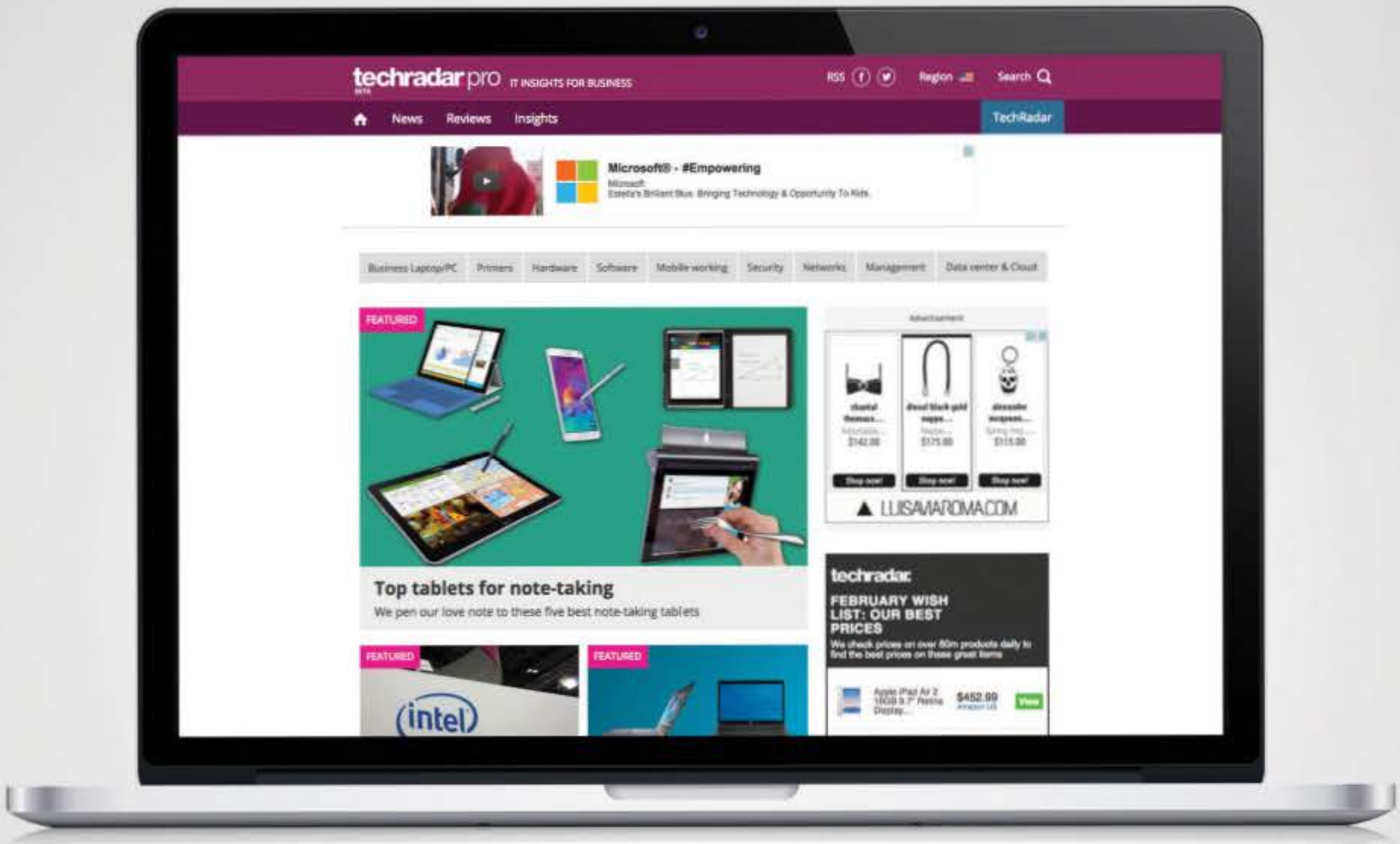
IT INSIGHTS FOR BUSINESS



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Alex Campbell

OPEN SOURCE

Working from Home? Try These Open-Source Tools

WITH THE SPREADING pandemic of coronavirus, or COVID-19, many companies are asking employees to work from home. For bigger businesses, enterprise solution offerings from Google or Microsoft might be the default, but some companies may not want to have to rely on Big Tech to get work done. Luckily, there are open-source alternatives.

A lot of workers will be working from home in the coming weeks. As a result, they will rely on communication and collaboration tools as stand-ins for being at their desks or in meeting rooms. There are offerings from the likes of Google, Microsoft, and Zoho, but there are lots of great open-source offerings, too.

I wrote recently about Keybase (https://keybase.io) and its collaboration tools. While Keybase's first goal is to facilitate easy encryption tools, it offers Slack-like teams and private chat. Keybase also offers private, encrypted online file storage (like Dropbox) that can be shared with individuals or teams. Keybase recently added a Google Meet bot, which when invoked with "!meet" creates a link to a Google video conference.

Slack and Atlassian's HipChat are big players, but to get the most out of them, you have to pay. There are two more platforms worth a mention, though. Rocket Chat (https://rocket.chat) and Mattermost (https://mattermost.com) are self-hostable Slack replacements available under the MIT license. The basic features (such as unlimited chat history) are free; enterprise licenses are required for more advanced features. Both have apps for iOS, Android, Linux, MacOS, and Windows.

For file-hosting, Nextcloud (https://nextcloud.com) has long been a staple solution. It offers a suite of plugins in addition to file-hosting and sharing capabilities. Plugins and features include team chat, calendars, notes, contact management, and more. For larger teams, I recommend hosting Nextcloud on a reasonably fast server and using a MySQL database instead of the default SQLite database back end. One of my favorite things about Nextcloud is the ability to use a ton of different storage back ends for files, including Google Drive, Amazon S3-compatible object storage, and more. I've had mixed results with its Android and Linux desktop clients, which can be buggy.

> One of my favorite things about Nextcloud is the ability to use different storage back ends.

Keybase added the ability to easily start Hangouts from team chats.

If you just need file storage and sync without the extra features of Nextcloud, SparkleShare (https://sparkleshare.org) offers a solid file-sharing and sync option. Both SparkleShare and Nextcloud can encrypt files at rest, so your files are only available via the application. This means that if your remote storage is compromised, your files remain unreadable.

For video conferencing, Google's Hangouts and Microsoft's Skype are big players, as is Zoom, which, depending on your experience, is either great or terrible. One of the open-source tools that can replace those services is Jitsi (https://jitsi.org). It isn't a standalone app, but a secure video-conferencing solution for other projects. Rocket Chat uses Jitsi to implement its video-conferencing capabilities.

Finally, I'd like to throw in plain old Git (with GitHub, GitLab, or another remote host). It's a great collaboration tool for text-based files. If your work lends itself to plain-text formats (Markdown, Restructured Text, HTML, LaTeX, etc.), consider using Git instead of the common filename madness of "document.doc," "document-1.doc," "document-1-final.doc," and so on.

There are a lot of open-source tools to help get work done while away from the office. Stay safe and healthy out there.

Alex Campbell is a Linux geek who enjoys learning about computer security.

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SPRING SALE

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THE LIST

THE BEST KEYBOARDS IN 2020

8

HYPERX ALLOY CORE RGB HyperX clearly decided to flex with the Alloy Core RGB, delivering an effective membrane keyboard that looks great for under 50 bucks.

7

LOGITECH G PRO X The G Pro X might appear at first glance to be feature-light, but the inclusion of easily swappable key switches for physical customization is brilliant.

6

CORSAIR K63 WIRELESS Corsair's high build quality and style make for an excellent wireless keyboard, complete with Cherry MX Red switches and a soft rubber wrist rest.

5

DAS KEYBOARD 4 PROFESSIONAL Functionality over frills. No key backlighting or dinky touchscreens here, just a solidly designed keyboard, perfect for typists who prefer mechanical keys.

4

STEELSERIES APEX PRO A sleek deck with RGB lighting, a tiny OLED display, and incredible customization, thanks to complete actuation point adjustment on a per-key basis using SteelSeries's own software.

3

COOLER MASTER MK850 Cooler Master might not be known for its keyboards, but the MK850 is a high-quality mechanical keyboard with all the usual bells and whistles, plus its unique analog key technology.

2

CORSAIR K95 RGB PLATINUM One of the best mechanical keyboards around, this oozes quality. It's a big, expensive setup, with dedicated media controls and textured WASD keycaps. We love it.

1

RAZER HUNTSMAN ELITE With Razer's opto-mechanical switches, this has near-instantaneous key response. Using light instead of physical contact pieces means keys are twice as durable as traditional ones.

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HEAD TO

BY **CHRISTIAN GUYTON**

Membrane vs. Mechanical vs. Optical Keyboards

Which type of keyboard is best? Mechanical keyboards have been around for longer, but were supplanted by keyboards with softer, quieter membrane keys. Some gamers swear by the clickety-clack of mechanical setups, while others favor the new kid on the block, optical keyboards, which use light rather than physical metal contact filaments. We're going to try to put this issue to bed, but we fear that even the *Maximum PC* team might remain divided....

ROUND 1

Value

Straight out of the gate, optical keyboards stumble. Using a combo of sturdy mechanical keys and lightbeam-based switches results in a costly manufacturing process, and optical keyboards tend to be expensive.

Membrane keyboards are almost unilaterally the cheapest option. Many business environments have made the shift to membrane keyboards, usually due to price and quietness. Generally, a multipurpose membrane keyboard is cheaper than a mechanical model with the same features, primarily due to the lower cost of the materials. Membrane key tech has effectively reached its apex, too, so industry efforts can be focused on making the production process more affordable.

Mechanical models sit somewhere in the middle. While the base technology behind mechanical key switches has been around for years, modern mechanical keyboards use delicate, expensive components in their key switches, and the tech is still being refined and improved. That's not to say that mechanical keyboards can't be affordable, but budget-friendly ones tend to be lower quality or feature-light compared to membrane keyboards of the same price. A clear winner, then.

Winner: Membrane

ROUND 2

Precision

Anyone who tries to convince you that membrane keyboards offer the best sensitivity and performance is wrong. Just wrong. Membrane keys do have advantages, but the precision of a mechanical key switch is simply superior. Cheaper membrane decks tend to have issues with key rollover, where rapid key presses fail to register separately, and many people find membrane keys feel spongy.

Some mechanical keyboards offer adjustable key actuation—the point to which a key must be depressed to register any input—and certain high-end units may even have keys with analog switches capable of registering variable inputs. Customization is often king when it comes to mechanical keyboards, with gimmicks such as swappable key switches (commonly Cherry's color-coded MX switches).

Mechanical and optical keyboards are great for registering rapid simultaneous inputs—ideal for gamers and speedy typists. Mechanical keys vary significantly when it comes to input response, with more expensive keyboards typically having less delay, but optical key switches register input at the speed of light, making optical keyboards the most precise of all.

Winner: Optical

ROUND 3

Feedback

Physical typing feedback can be crucial when deciding what keyboard to buy. If you don't like how using it feels, you're not going to want to type on it every day. This is tricky for us to judge; this very writer prefers a flat, quiet membrane keyboard for office work, but craves chunky mechanical keys for gaming. Personal preference is a major factor.

Mechanical keyboards can have a variety of key press responses, from smooth Cherry MX Red switches to the more tactile MX Greens, which have an audible click and require more force to press. Optical keyboards use fixed LEDs and light sensors, so the actuation point usually can't be adjusted and key press sensation is more in control of the manufacturer.

Membrane keyboards, on the other hand, tend to have less key travel and a more squishy typing sensation, as the base of each key presses against the flexible membrane below to close an electrical circuit. The membrane isn't as solid as the springs in mechanical and optical keyboards, but some users prefer that; for us, though, a sturdy mechanical key is more satisfying. You know when you've accidentally hit a key on a mechanical keyboard, which is why they get the win.

Winner: Mechanical

HEAD

From left to right: **Many mechanical switches have colored stems to indicate their resistance and sensitivity. Optical switches work by interrupting the path of a light beam to a sensor. Membrane keyboards can be thinner and lighter due to the reduced travel of the keys.**

ROUND 4

Ease of Use

Membrane keyboards are quiet. Without a physical switch beneath the key, much of the noise produced by the keyboard is reduced or absorbed by the membrane underneath the keycap. Mechanical and optical models can be clattering monstrosities under the fingers of a fast typer. A physical switch produces more noise, and while optical keyboards can be slightly quieter than their mechanical brethren, both are beaten in the sound stakes by the mighty membrane.

Membrane keyboards tend also to be lighter and smaller than the others; their composition uses fewer metal components, and membrane keys can sit flush with the rest of the board due to their reduced travel. Only a select few could bear using a mechanical keyboard on their lap, while membrane ones can be incredibly light and thin.

Mechanical keyboards (and most optical ones) are easier to clean, as each key can be removed without the need for any tools. Blast compressed air into the space below and boom, clean keyboard. The keycaps can usually be washed separately, too. Membrane keyboard users don't enjoy this luxury, but they're still easier and quieter to use, so they win this round.

Winner: Membrane

ROUND 5

Durability

This is where membrane keyboards really fall down. Where a mechanical or optical key will, in most cases, retain the same pressing sensation for its lifespan, the squishy layer beneath the keys of a membrane model wears away, changing the feel of the keys.

Mechanical keys last longer and the switches are also relatively straightforward to replace. Membrane keyboards are significantly harder to repair should a key fail, but will likely need replacing long before that point, due to the membrane wearing thin.

In terms of day-to-day use, optical keyboards have the longest lifespan. The key switches last longer than mechanical keys, due to the lack of delicate electrical contacts, and the key switches are usually simple to replace. So, why do mechanical keyboards win? While mechanical key switches might wear out a bit faster than optical ones, mechanical keyboards are more robust on the whole. Tiny light sensors and emitters mean that optical keyboards are more susceptible to damage, dust, and electrical failure. Mechanical keyboards last for ages, and if you drop one, the most you'll likely have to do is pop a few keycaps back on.

Winner: Mechanical

And the Winner Is...

It's a tie! Well, a tie between mechanical and membrane keyboards. The fact is that optical keyboards are a lot more niche, pricier, and don't really perform noticeably better than their high-end mechanical counterparts. Both mechanical and membrane keyboards have their advantages and disadvantages; you must consider the purpose you need a keyboard for.

If you're working in a crowded office, a noisy mechanical keyboard is a great way to annoy coworkers, but its improved precision makes it ideal for gaming at home. It's hard to say which type of keyboard is objectively better, because they both have their shortcomings. Some people prefer squidgy membrane keys, and some like the firm, responsive click of a mechanical switch.

We'd give the edge here to mechanical keyboards, but that does come down to personal preference. The significantly better lifespan of mechanical and optical keyboards makes them, at least in our eyes, worth the higher asking price. Ultimately, though, the best type of keyboard is the one you like using.

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DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> VPN Varieties
> Weird Wake-Up
> Mouse Mystery

Which VPN Option?

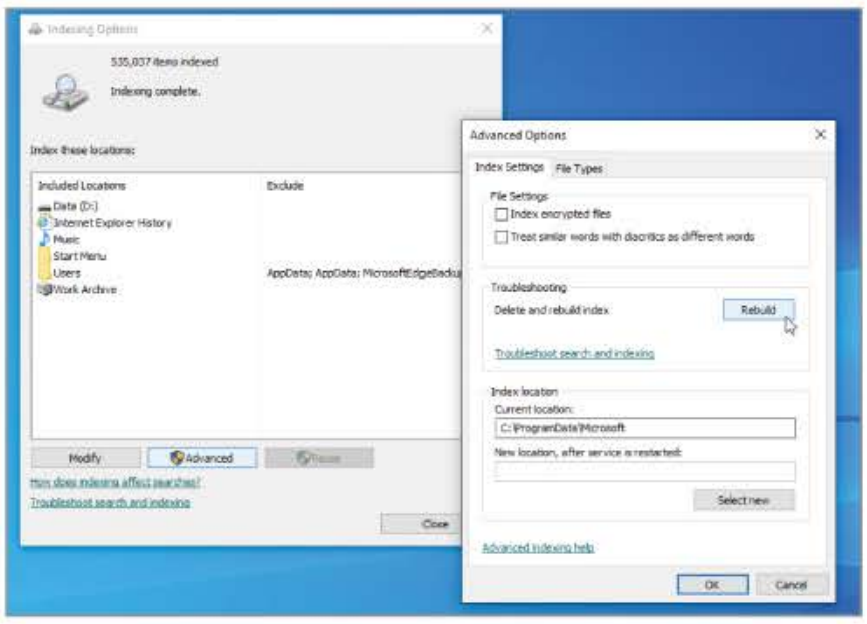
I'm considering ditching my monthly-fee VPN service for my own home-brewed VPN. While I have no doubt there are Internet how-to guides and *MPC* tutorials, what is the short answer? I have a TP-Link Safestream VPN router collecting dust, or my current router supports easy setup using OpenVPN, so are these two relatively easy viable alternatives? Does a secure VPN require serious hardware, or is there a poor man's alternative to pay services? **– Ryan Pitts**

THE DOCTOR RESPONDS:

Your question has given the *Max PC* team an idea, and we'll be revisiting this subject in greater detail in a future issue. For now, remember that third-party VPN providers offer a different service from a VPN server sitting at home. A home-brewed VPN server is best for allowing you to "dial" into your home network securely when out and about. It creates a secure, encrypted tunnel that extends your local network to specific devices on the road, allowing them to access services as if you were at home.

Fee-based VPN providers work differently—their encrypted tunnels are designed to connect your devices securely (and anonymously) to the Internet itself. While you can configure a home VPN server to provide an encrypted tunnel to the Internet for extra security, your home's public IP address (the one that identifies you on the Internet) isn't masked.

Long story short: If remaining anonymous or accessing geo-restricted content are your reasons for using a VPN, you need to stick with a third-party provider. If your budget is stretched, consider looking at Windscribe (https://windscribe.com). Its free tier offers a choice of 10 locations, as well as 10GB of free monthly bandwidth, adequate for most moderate-use cases.



A corrupt Windows Search index can bring File Explorer to a halt.

Sluggish File Explorer

Last year, I upgraded my system to an AMD Threadripper 2950X from a quad-core Intel CPU, and I expected a big performance increase, which did not happen. My system runs reliably, but it's s-l-o-w. Sometimes it takes 10 seconds to open Windows Explorer. Everything is slow. I read a lot about how picky Threadripper is concerning RAM, and I purchased memory that was on the Gigabyte memory compatibility list, but I'm wondering if the RAM is slowing everything down.

Windows is running off an M.2 boot drive (Samsung 950 Pro, 512GB), with five internal traditional spinning-platter disks offering a total capacity of 31TB. I'm hoping you can tell me if I have components that are not optimal, or some possible reason the system is so slow, and/or what I might do to increase the performance. I'm not overclocking it. The CPU stays cool with the liquid cooling system.

I use the system mostly for software development and often have one or two virtual machines running, but even with no VMs it's still very slow. **–Hal Endresen**

THE DOCTOR RESPONDS:

You're not going to notice a stellar increase in the day-to-day performance of your PC when upgrading from an older quad-core chip to a Threadripper—basic Windows usage benefits most from a faster hard drive, which you've already got in place in the form of the M.2 drive.

That said, things certainly shouldn't run slower than before—you don't mention

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↘ submit your questions to: doctor@maximumpc.com

if your latest incremental upgrade was accompanied by a fresh Windows install, which is a must when swapping out motherboard, CPU, and RAM. If this isn't the case, perform a clean reinstall to see if the problem clears (image your current setup first, then roll back if the problem persists).

We suspect you've already performed this step, in which case we suspect your sluggish performance is related to File Explorer's slow opening times. There are literally dozens of potential causes—and solutions—to wade through, but the Doc's hunch is that this is a problem with the Windows Search index, linked to the gargantuan amount of storage attached to your PC. Windows Search can end up consuming vast amounts of CPU cycles and RAM attempting to index large folders, and the problem can be exacerbated by a corrupt index. One symptom of this? File Explorer takes an age to open.

To see if you can resolve this, type "index" into the Search box to open Indexing Options. Click "Modify" to check the current indexing options. Try removing large folders from this list, then click "OK" followed by "Advanced" to click "Rebuild" and flush and rebuild the index. Hopefully, you'll immediately feel the benefit.

If not, use a free tool like HDDScan (https://hddscan.com) to check your drives' physical health and SMART status, then run a full series of health checks on the drives and Windows itself—start with a disk check on each drive. Open an elevated Command Prompt and use "chkdsk c: /f/r" to schedule a boot check when prompted, then repeat the command for every other drive. After rebooting, if Windows finds and fixes errors, you'll almost certainly see improvements.

Still having problems? One more thing to try: If File Explorer opens to the "Quick Access" folder rather than "This PC," a shortcut to a currently inaccessible folder—typically an unconnected network drive—could be holding things up. Try removing this or switch to the File Explorer ribbon's "View" tab and choose "Options → Change folder and search options" to set "This PC" as the default to bypass the problem.

Wake-Up Conundrum

Doc, my desktop PC has been randomly waking itself up in the night for some time now. This wouldn't be much of a problem except it doesn't go back to sleep on its own despite normally sleeping perfectly. I've used my nine years of reading experience to troubleshoot, making sure no backup is scheduled, not participating in any reporting, and so on. "Powercfg -lastwake" finally yielded the culprit: a nightly Windows Media Center wake timer. What?! I upgraded to Windows 10 years ago and have shaken my fist many times at Microsoft for taking that beloved software from me. I've deleted the offending task, so hopefully it cures my PC's insomnia, but are there whisperings of WMC being brought back, or is this a perfect example of why you recommend clean installs every now and then? Thanks!

–James Breen

THE DOCTOR RESPONDS: Congrats on performing a textbook diagnosis of your problem. There is little chance Microsoft will resurrect Windows Media Center (if you've not already done so, install Kodi—www.kodi.tv—with live TV support, following our tutorial from the July 2017 issue), so the offending task does not foretell its return.

Ultimately, you've answered your own question: If you've never reinstalled Windows from scratch since upgrading to Win 10, this is almost certainly a leftover from your Win 7 install. We suspect it may have been waking your PC every night since you upgraded, but it's only recently something has prevented it from going back to sleep again—it may, for example, be related to the sleep-related problems reported (among many other glitches) with the recent KB4535996 optional Windows update.

We recommend you bite the bullet and perform that clean reinstall; most Windows installs need clearing out every two or three years—particularly now Windows insists on six-monthly refreshes. Not only will you banish gremlins like this, but you'll end up with a leaner, faster system.

Safe or Scam?

Do you have any information about a program called Advanced System Repair Pro? I've seen various reports that it is a "scam," doesn't work as advertised, and corrupts hard drives, but others say it works as advertised. **–Mike Becker**

THE DOCTOR RESPONDS: We clicked the link Mike sent us, and it was blocked by Malwarebytes on the grounds of it being a "Potentially Unwanted Program." The Doc then visited the site on a sandboxed PC and saw it was simply another in a long line of system maintenance apps promising a collection of miraculous optimization, repair and malware-cleaning tools. The Doc is naturally suspicious of all such programs, so stay away from this—and indeed any all-in-one tool with components like Registry cleaners that have at best a placebo effect and at worst the ability to screw up your Windows installation.

Mouse Startup Glitch

I'm having an issue with my mouse not being recognized at startup. When I power up my computer, the mouse isn't recognized, but unplugging it from the USB port and plugging it back in makes it work. What's strange is that it happens only about once in every four boots, and there's no pattern to its behavior.

I've tried every rear USB port and it happens in all of them. Updating the mouse firmware and motherboard drivers doesn't help. Is there a BIOS or some startup setting I may be missing? The computer is a year old now, but the mouse never had any problems on my prior build.

The mouse is a Corsair M65 RGB and I'm running a Ryzen 5 2600X on an MSI X470 Gaming Pro Carbon, with 32GB HyperX Predator RAM, and an M.2 NVMe Samsung 970 Pro as the boot drive. My mobo drivers are all up to date and I'm running Corsair's iCUE for the mouse (firmware v 3.02). Thanks for the help, Doc!

–Isaac Peterson

THE DOCTOR RESPONDS: This is a known issue with the Corsair M65 RGB—you're not alone in complaining about the mouse occasionally failing to be spotted at startup. It appears Corsair's iCUE software is to blame—try reflashing the firmware. Unplug the mouse, then hold down the left and right mouse buttons before plugging it in. iCUE should prompt you to update the firmware.

Assuming this doesn't work, try the following workaround, which prevents iCUE from starting with Windows, and ensures your mouse works in basic mode on every boot. You'll have to create a shortcut to launch iCUE manually when you need it, but at least you won't have to keep stressing the USB port by unplugging and plugging in the mouse to get it to work.

To stop iCUE from launching with Windows, first disable the Corsair Service entry—press Win-R, type "msconfig" and hit Enter, then uncheck its entry on the "Service" tab. Once done, switch to the "Startup" tab and click "Open Task Manager" to jump to its "Startup" tab. From here, right-click the iCUE entry and choose "Disable."

What parts to pick, tube bending techniques, and more, *by Zak Storey*

THE ULTIMATE GUIDE TO LIQUID COOLING YOUR PC

THERE'S NOTHING QUITE LIKE having a custom-built liquid-cooled PC. There's something about configuring every last element of your rig that gives you an incredible feeling of satisfaction. Compare it to restoring a classic car. You know each and every component that you've bought, how it works, how you installed it, where the problems might lie, how to fix it when it goes wrong, and best of all, you know that it's going to perform better than it did before, and it's unique. Much like that restoration, with liquid cooling you become attached to your work; it suddenly has a personality, a soul, a temperament, and it's a machine that you'll remember for years to come.

Yet deciding to embark upon this advanced mode of PC building can be daunting. It requires in-depth knowledge of a vast multitude of parts, intricate experience and instinct that sometimes can't be taught. And, of course, there's plenty of room for failure, especially when mixing electricity and H_2O.

That said, we recommend that every PC enthusiast and system builder tries liquid cooling at least once. A lot of these problems can be overcome with some smart planning, time, and a little knowledge. And better yet, the benefits to your system extend far further than just looks. Whether it's the extra overclocking headroom or the reduced overall noise, we believe it's well worth the investment. In fact, that last part is probably the biggest bugbear you'll find when it comes to liquid cooling your rig: cost. However, the reality is that you really don't need to spend all that much on it. You can easily convert a fully built system to liquid cooling, chilling both the GPU and the CPU with copper components, for just a little over $400. That's still a fair amount of cash, sure, but not quite the $1,000-plus spec lists that we often throw at our builds. Of course, with more investment comes better performance and an easier build process, but that's not always necessary, and a bare minimum loop when it comes to fittings and complex components will likely yield similar if not identical results if configured correctly.

This issue, we're going to divulge all of our liquid-cooling secrets and give you the deepest-level low-down, so you can decide whether it's worth making the commitment to build your own unique rig that's perfect for you.

STEP-BY-STEP GUIDE

Build this kick-ass ITX gaming PC

PG. 56

Parts & Options

When it comes to planning your loop, the range of products available—from fittings to tubing, and radiators to reservoirs—makes for a daunting prospect for the uninitiated. So, let's break down exactly what you'll need, and what you can buy to perfect your liquid-cooling loop.

Tubing Types: Soft Tubing

Typically manufactured from PVC, or polyvinyl chloride, soft tubing is flexible, easy to cut, affordable, and comes in a variety of different diameters and thicknesses. Although usually clear, you can find opaque colored or translucent frosted variants as well. It's easy to use and cut to length—in fact, you can get away with just using scissors if you really want—which makes building a loop with soft tubing a great choice for beginners. Downsides typically come in the form of reduced bend radii, and it also has a bad habit of leaching color over time.

There's another type of soft tubing worth mentioning here, and that's EPDM, or synthetic rubber tubing. Unlike PVC tubing, EPDM only comes in matte or gloss black. It can maintain tighter bend radii, thanks to its thicker internal walls, and also doesn't suffer from color leaching at all. This type of tubing was originally designed for industrial use, and as such, is ideal for those looking for minimal loop maintenance, or for a more grungy aesthetic for their loop.

Soft tubing is great for those starting out with liquid cooling.

COOLING THEORY

Most CPU towers consist of small vacuum-sealed chambers containing a tiny amount of fluid. When heat is applied to this fluid, it evaporates and disperses to the extremities of the pipes. The vapor then condenses, thanks to cool air being pushed over it, then descends through a wicking material back to the source of the heat to repeat the process again.

With liquid cooling, a similar principle is applied on a grander scale. Instead of a small amount of vapor you have massive volumes of coolant, instead of convection, you have a pump, and instead of the vapor hitting the top of the heat pipe and disseminating the heat through the tower's fins, the radiator channels disperse the heat across its fins, then it's cooled by fans again.

This is why liquid cooling makes such a big difference. It's far easier to move the heat away from hot components quickly, then disperse it across a bigger surface area, cooled by more fans. An additional benefit is that as the radiators are usually located on the outer edges of the chassis, heat is expelled immediately, rather than lingering, reducing the ambient temperature around secondary components.

Tubing Types: Hard Tubing

The most popular type of hard tubing is made from acrylic. It's a strong, clear, hard-tube, usually coming in straight lengths of about 20 inches or so. It can be bent to shape using a silicon insert and a heatgun, and typically needs its edges cutting to size and chamfering off, so it can fit within its compression fittings. Like soft tubing, it can leach color over time—however, that usually only happens when it's situated in direct sunlight for long periods of time. Although it's almost always clear, you can find frosted versions as well. The only downside to acrylic tubing is that it does have a tendency to shatter when hit hard enough. Which is where PETG comes in.

PETG tubing and acrylic look almost identical, yet the two have very different material characteristics. PETG has slightly less clarity than acrylic, and additionally features a far lower melting point, making it easier to bend. The big advantage, though, is that it doesn't shatter under pressure; instead, it compresses when force is applied.

You can also get borosilicate glass tubing, which apart from being PH neutral and impermeable, features the highest clarity of all tubing types. Typically used in straight lines with angled extensions, it can also be bent with a blowtorch and skill. Finally, there's annealed copper tubing, which can be plated in zinc, chrome, or other metals, or powder coated. To bend this, you need a fairly heavy-duty mandrel.

Although it requires extra skill, hard tubing looks much neater.

Fittings

A good rule of thumb is to remember you'll need at least two basic compression fittings for each liquid-cooled component. Outside of standard fittings, there's a ton of different types out there, so let's break them down.

Compression Fittings

These are the main fittings for connecting tubing to hardware. They come in a variety of sizes, and vary depending on the tubing type you use. Some are for hard tubing and some for soft. As standard, on the male end of a hard tubing compression fitting comes a G1/4-inch thread and an o-ring, to stop leakage. Remove the compression cap on the female end, and you'll see another two o-rings inside the fitting. This is where you'll push the chamfered edge of your tube in and past, before sealing it with the compression cap, which features an additional o-ring. Soft tubing compression fittings are very similar. They still have a G1/4-inch thread, and an o-ring on the male side, but once the compression cap is removed, there's a metal barb beneath that the tubing slides over. Once the tubing is on the barb, the compression fitting secures on its thread and compresses the tube on to the barb.

Miscellaneous Fittings

There's also a number of specialist fittings that you need to know about. Ball valves are an important one—they enable you to close and open a valve to allow coolant in or out (this is ideal for loop maintenance). Pass-throughs enable you to drill holes directly through a case panel, and provide a female G1/4 thread on either side. Plugs literally just plug a G1/4 port. Meanwhile, T, Y, and X junctions enable you to move coolant in multiple directions from a single point, and quick disconnects give you the option to disconnect entire lengths of tubing quickly and easily, and then rejoin them with minimal coolant loss, making them perfect for builds where you need to swap out or test hardware on a regular basis.

Angled Fittings

A branch of extension fittings, these fittings can provide dramatic angle adjustments in a very tight radius. Most of these are rotary fittings, too, meaning they can be adjusted to point in any 360-degree direction. You'll usually find 33, 45, and 90-degree angled fittings, and sometimes even twin 45-degree fittings as well (with two rotary joints to allow for more flexibility and orientations).

Extension Fittings

Extension fittings increase the distance between the liquid-cooling hardware and the next fitting. They come in all sorts of lengths, can be daisy-chained, and can even feature male-to-male connectors to join two bits of cooling hardware together.

Waterblocks

If it produces heat, there's probably a waterblock for it. That said, these are often the simplest part of speccing out your liquid-cooled build. The only thing you need to be aware of is compatibility. When it comes to a graphics card, you're going to want to make sure that the waterblock is compatible with the PCB on the card. Aftermarket graphics cards typically have custom PCB designs with different VRM locations and more, so not all reference waterblocks will fit them. Most waterblocks are designed for reference PCBs, but many manufacturers do offer additional blocks for bespoke models. Always double-check for compatibility before you buy.

The same goes for processors—although most blocks have mounting solutions for both Intel and AMD CPUs included as standard, some don't. The big exception is, of course, Threadripper, because its CPU die is far larger than that of the average chip.

Motherboard monoblocks, on the other hand, are a bit more complex. They're designed to reduce heat on the CPU's VRMs and MOSFETs, while cooling the processor at the same time. Because many motherboards feature unique layouts with regard to power delivery, these are often only provided for select mobos within a manufacturer's range.

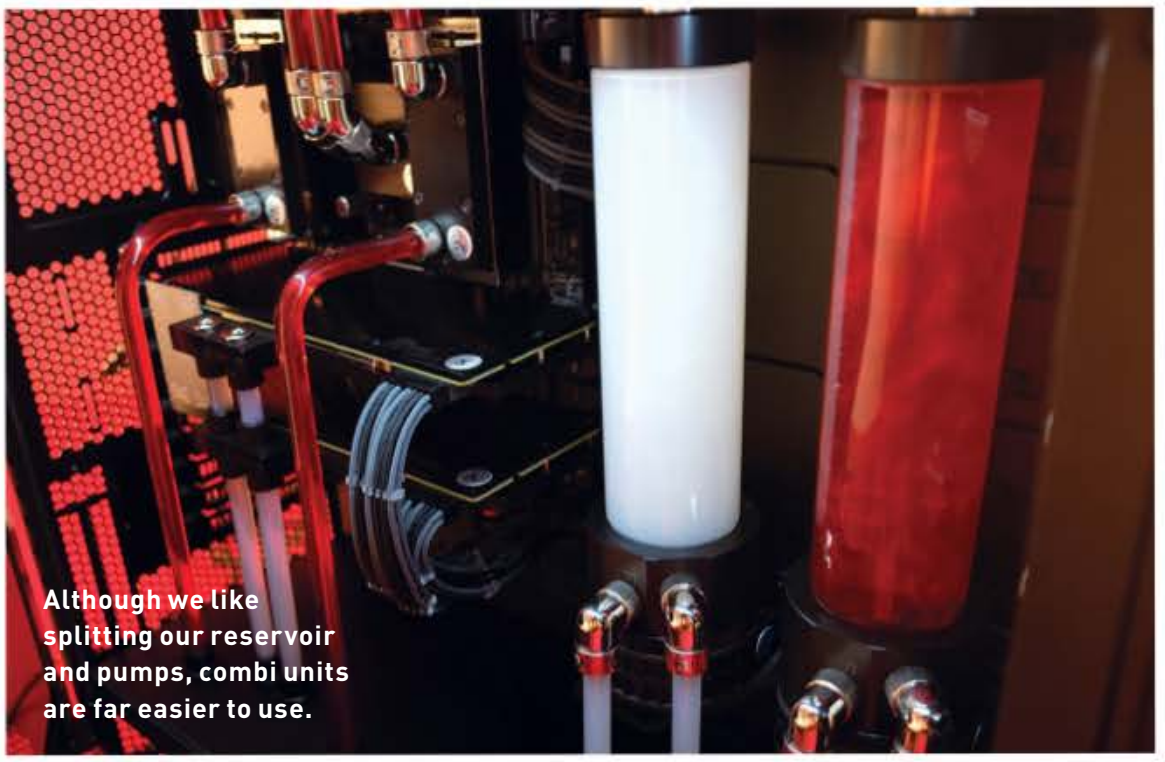
A good waterblock can really make your build shine.

Main Ingredients

Reservoirs & Pumps

Reservoirs come in all shapes and sizes. Most common are cylindrical tubes with ports on the bottom and top, or integrated with a pump. However, distribution plates, 5.25-inch bay reservoirs, and rectangular reservoirs are also available.

As for pumps, almost all of them are manufactured by a single company, Laing, then distributed to liquid-cooling brands, which house them in their own products. There are two main pump types, the D5 and the DDC. The D5 is a large form factor pump, ideal for liquid-cooling systems with multiple radiators, reservoirs, and waterblocks, whereas the DDC has a far smaller footprint, and is ideal for small form factor and ITX PCs.



Although we like splitting our reservoir and pumps, combi units are far easier to use.

Fans

We recommend fans with a high static pressure and a low noise rating. One of the best things about liquid cooling is it gives you a smoother way of dissipating heat by using more fans at lower RPMs.

Typically, with a CPU tower, the heated vapor needs to be cooled immediately, so it can do its job again, and it spikes in temperature as soon as the CPU is under load. With liquid cooling, because there's so much coolant being pushed by the pump, the coolant has a far higher thermal capacity, giving you time to cool it down via the radiator's far larger surface area, with more fans. So, you can run more fans at lower RPMs, reducing noise, while still extracting heat from the coolant adequately to keep everything running smoothly.

For most of our liquid-cooled builds, we set the fans to 30–50 percent of their total RPM and leave them there. This is fantastic for those frustrated with loud fans or in noise-sensitive environments. Take a Corsair ML 120 Pro, for example. At max speed, it hits 37dB(A), but drop it down to 1,000rpm (half its max speed), and it only reaches 18.5dB(A)—that's the difference between a busy office and a whisper, and yet it'll still be pushing close to 2.1mmH_2O, which is more than enough to cool our low fin density radiators.

Radiators

Radiators are the primary means for you to remove heat from your system. Most radiators come in sizes that are derivatives of either 120mm or 140mm, in the same manner that PC case fans do. So, you get 120/140mm, 240/280mm, 360/420mm, and 480/560mm radiators, going from one fan all the way up to potentially four fans per side. On top of that, they can be far thicker than a standard AIO radiator. Taking EKWB as an example, its SE (slim edition) 120mm radiators are 28mm thick—that's about the same thickness as the radiator used in the Corsair H100i. Most regular custom loop radiators are considerably thicker than that, with the average being around 40mm or so.

When it comes to radiators, there are two things to take note of: Firstly, you're going to want at least 120mm of surface area per component you want to cool (double that for overclocking), and secondly, you need to pay attention to fin density, or FPI. The higher the density, the more static pressure you need to effectively push air through it. In the case of that H100i we mentioned earlier, it has a fin density of around 21 fins per inch, compared with a 240mm super-thick XE radiator from EK, where you're looking at just 16fpi.

Preparation

Planning Your Perfect Loop

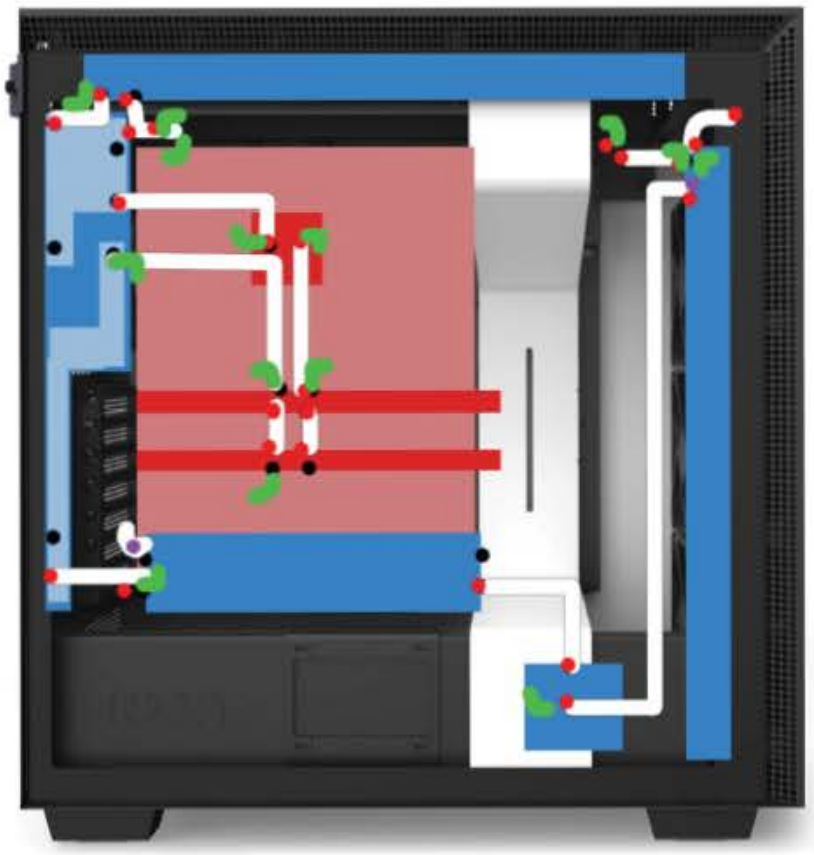
Now you have an understanding of all these different components, it's time to decide what kind of loop you want to build, how you're going to build it, what case you're going to use, and more.

You might already have a chassis in mind, or maybe you're keen to reuse your own—regardless, whatever you pick, we recommend it has good radiator support and strong intake air access. For a beginner, a big mid-tower case will help significantly when it comes to crafting your loop.

Something such as Fractal Design's Define R6 or the Phanteks Enthoo Evolv X are great options for rookies because they provide solid airflow and plenty of support for liquid cooling right off the bat.

The best thing you can do before you begin is research the chassis you have in mind. Strike up its name on Google, add "liquid cooled build" to the end of it, and see what results you get. When we plan our systems here at *Maximum PC*, we do that first, then head to http://pcpartpicker.com and http://builds.gg to check out the build logs there.

Once your case is selected, you'll want to grab a pencil and paper next, and start drafting your loop design. You could do this in Paint or Photoshop, too, but either way, you want to roughly sketch out your chassis and start planning your runs. This is also a good opportunity to figure out how many fittings you'll need. It does require a fair bit of brain power to visualize your internal layout and what angled fittings you'll need, but it's a quick and effective method to figure it all out. It's worth noting that, inevitably, your finished system won't look like your plan—you'll likely have to adapt to problems on the fly—but it gives you a good basis to work from.



Manufacturer Choices

There are numerous manufacturers that provide liquid-cooling hardware, from the sharp crisp waterblocks of EKWB to the glamorous fittings of Bitspower and the potent performance-heavy radiators of Alphacool. You can generally mix and match as you please, because most liquid-cooling hardware abides by the same standards.

However, one thing to be aware of is copper versus aluminum cooling. There are plenty of aluminum liquid-cooling products, which are usually cheaper than copper parts, but they cannot be used with copper components. If you're going aluminum, everything has to be aluminum, no exceptions. Reason being, the two metals (copper and aluminum) react with one another in the coolant (the coolant acts as an electrolyte, and galvanic corrosion occurs), leading to potential gunk build-up in the loop, and damage to the aluminum parts over time.

This can also happen depending on the type of coolant you use, because many coolants take advantage of biocides and other chemical procedures, some of which react poorly with nickel plating, so we always recommend you go with trusted coolant manufacturers.

THINGS TO CONSIDER

When it comes to planning your loop, you should keep a few key rules in mind:

1 Make sure your pump is gravity fed. There's nothing worse than running a pump dry—you'll damage it in the short term, and kill it in the long run.

2 Think about loop maintenance. Eventually, you're going to have to change the coolant. It could be six months, it could be three years, but it's coming. Think about where your drain port is going to be and where your fill port is going to be. Typically, your drain port should be located at the lowest point of your loop, and the fill port above the res.

3 Aesthetics or performance? This next one is pivotal. By far the most effective liquid-cooling loop for pure performance is a serial one, connecting one component to another, and so on. However, you'll often find folk (ourselves included) running parallel loops. This is because they look better, but performance tends to be worse, especially with low pump speeds.

4 Compatibility. Always think about what happens if something goes wrong. This is less of an issue with soft tubing, but if you have to reseat your memory, and there's a hard tube running across the top of it, you'll have to disassemble the entire system.

Techniques & Skills

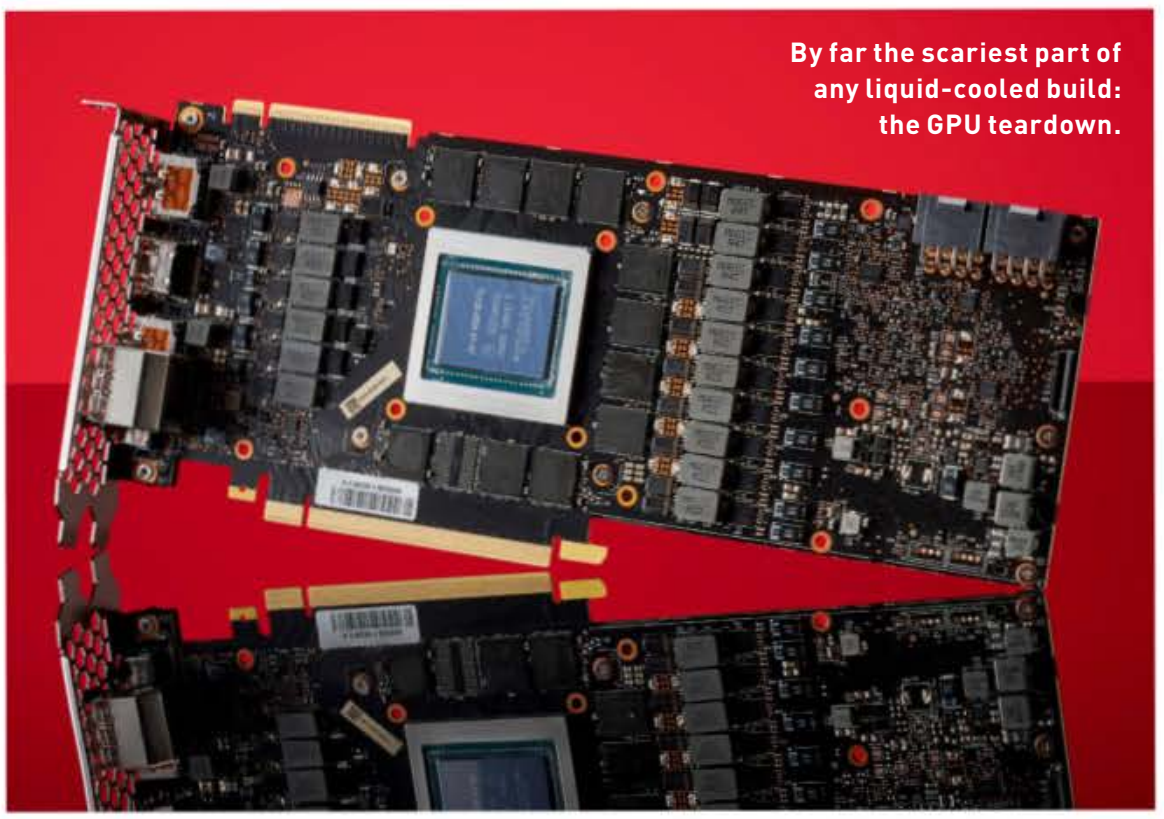
Now you've got everything planned, measured the case, and ordered the parts, it's time to get on with the build. The first and most terrifying part of the process is the graphics card disassembly. This is perhaps the most dangerous part of liquid cooling. If you get it wrong, and knock off a capacitor or a memory chip, your GPU is as good as dead. And you can bet your bottom dollar few manufacturers will honor the warranty if that happens. So, where do you begin?

Process

Well, you've bought your waterblock and you know it's compatible with your GPU. Now you're going to begin to strip down the graphics card. To do this, first remove the backplate—you'll find tiny Phillips head screws here, but a small precision screwdriver should do the trick. Once the backplate is off, you'll be able to work out how the rest of the card is secured. Remove all major screws, and identify where the cooler itself attaches to the PCB (there's usually one or two screws connected to the rear I/O plate as well). Be sure to detach any fan or RGB headers, and very carefully prize the two cards apart, slowly rocking it back and forward. The last thing you want to do is rip anything off. Word of advice: For those disassembling a Founders Edition graphics card, the screws underneath are 4mm or 3/8-inch hex screws—you really ought to use the correct socket to remove these; you can use pliers, but there's a higher risk of knocking off a capacitor from the rear.

With the cards prized apart, you can then remove any additional plates or support brackets on the graphics card, and then it's time to clean up the GPU itself. Remove any remaining thermal pads from the memory and the VRMs, then clean off the GPU, preferably with an alcohol wipe or a microfiber cloth coated in 99 percent isopropyl alcohol.

The next step requires you to refer to your waterblock manual, because each block has different mounting mechanisms. They usually ask you to apply a thermal pad to each of the memory chips and to the power delivery. Then it's a case of applying thermal paste to the GPU directly, before you begin the process of adding the waterblock to the card. Line the block up with the screw holes around the GPU, and carefully place the block into position. Now, secure the block around the GPU first, screwing the included screws down in a hexagonal sequence. Then it's a case of installing the remaining screws into the GPU block and you'll be good to go. One thing to note: Once the four screws surrounding the GPU are in position and the waterblock is relatively secure, if you have a backplate, now is the time to check the manual to identify which screws you need to leave out, because the backplate will need to be secured via additional threads.



By far the scariest part of any liquid-cooled build: the GPU teardown.

PRE-BLOCKED GPUS

If you're not sold on stripping down your pride and joy to liquid cool it, there is, thankfully, a fairly good alternative out there, although it might be a bit pricier. A lot of manufacturers now offer a pre-blocked version of their highest-end graphics cards. EVGA has its Hydro Copper line, Gigabyte has the Aorus Xtreme Waterforce, and Zotac has the ArcticStorm. All of these cards come with a warranty and often only cost $100–200 more, which, let's face it, is the price of a good waterblock anyway.

However, there's one significant drawback to all of this, and that's the fact that you can't use these cards outside of their liquid-cooled environments. All of them require you to install a full loop before you can even test that the GPU itself is functional. Now, that's an issue, because we know liquid cooling isn't an easy task, and building a loop to then have to strip it because you have a dud graphics card is going to take a considerable amount of time.

On top of that, when you're upgrading to your next rig or graphics card, it's far harder to sell a card that has a waterblock on it than one on which you can reinstall its original stock air cooler.

Tube Tips

How to Use Soft Tubing

The issue with soft tubing is less to do with the process of fitting it, and more to do with identifying how to run a length of it. It's all to do with bend tolerances. The shorter the length, and the tighter the bend you want, the more likely you are to kink it. If it kinks, coolant can't flow around the loop, temperatures sky-rocket, pressure can build up, and it can damage the components within the loop. This is why it's useful to plan the loop out beforehand, and even include a few 90-degree extension fittings here and there. A clean soft-tube build typically requires quite a few angled fittings.

That aside, how do you actually do it? First, attach your soft-tubing compression fittings to the two components you want to connect. Then remove the compression caps from both fittings, revealing the barb underneath. Now take your coil of soft tubing, and run a length of it between the two fittings. Make sure you measure from the bottom of the barbs when you do this. Next, cut off slightly more tubing than you think you need. You can always shorten a length of soft tubing later.

Now you're going to take the compression cap and slide it along the tube, making sure it's in the correct orientation to secure itself back on to the fitting. Next, take a pair of needle-nose pliers, insert them into the end of the tube, and then carefully stretch out the bottom of the tubing in both directions. Now you can wiggle that stretched part of the tube on to the barb and past the lip of the fitting. Finally, secure the compression cap back on to the fitting, and repeat the process at the other end.

You can usually cut soft tubing with a good pair of scissors.

Tube Bending

When it comes to tube bending, we always recommend that you stick to a single 90-degree bend per length of tube. In fact, take a look at any of our custom liquid-cooled builds that we've done over the last two years, and you'll notice almost all of the runs feature single 90-degree bends. Secondly, always, always, always cut off more than you think you need. You can always reduce the length of tubing, but it's impossible to increase it without leaning on extension fittings, and that can look ugly. So, where do you begin?

Well, you're going to need a heatgun that can be placed on its back with the nozzle pointing up, a silicon tube insert that matches the ID (inner diameter) dimensions of your tubing, a hacksaw specifically designed to cut acrylic, a deburring tool to chamfer down the edges (sanding paper also works), and a vice grip to cut your tubing lengths with. Most of these you can buy as a kit from a liquid-cooling manufacturer.

Once you've gathered all that together, wet the silicon insert (having a bowl of water to hand helps here), and insert it into the tube. Then set your heatgun on a medium setting, and carefully hold the tube above it in the middle, three to four inches from the tip of the gun. Rotate the tube while moving it back and forth across the heat. This heats the entire area and helps prevent kinks forming in the tube when you perform your bend.

This next step varies depending on whether you're using PETG or acrylic, but over time, you'll notice the tube becomes more malleable where you're heating it. Once it becomes flexible enough, slowly and carefully bend it into a 90-degree angle. To do this, you can line it up with the corner of a table, a case, anything. Once you've got the angle just right, carefully lower the heated tube into your bowl of water to cool it down, then remove the silicon insert.

To fit it, remove the compression cap from the fitting—being careful not to lose the o-ring—pop the cap on the length of tube, followed by its o-ring, then push it into the compression fitting, past the two internal o-rings. Once done, move the external o-ring down to the thread, bring the cap down, and secure it in place. Repeat this process at the other end, and your first tubing run is complete.

It's always smart to keep heating the outside edge while you perform the bend.

Cool Runnings

Final Steps

Now you're almost there. Your system's built, your waterblocks are in place, and you've finally got all your tubing runs nice, tight, secure, and in position. There's a few checks you need to perform before you commit any coolant to your system.

1 **Double-check all your fittings have o-rings and are compressed and tight. This goes for reservoir caps as well.**

2 **Make sure any excess G1/4 ports—on graphics cards, pumps, reservoirs, or radiators—are sufficiently plugged with plug fittings.**

3 **Make sure all of your PSU power cables are unplugged from your motherboard and graphics cards, so they're not providing power and therefore heat during the priming process.**

4 **Make sure you have a PSU bridge attached to your power supply's 24-pin ATX cable, so you can power up the pump and fans without turning on the system. You can pick these up cheaply from most liquid-cooling stores.**

5 **Place paper towels underneath any point where a tubing run connects with a fitting, or a fitting connects with a thread.**

6 **Plug your power supply into the wall, ensuring the switch at the back of it is turned off.**

Once those checks are complete, you're ready to begin filling your loop. Open your fill port (or the reservoir, if you're lazy like us), from the top, and begin filling your loop with your chosen coolant. Fill the reservoir until it's about 75 percent full. Then turn on the power supply, using the power button to the rear of the PSU. You should see and hear the pump turn on, and the coolant drain out of the reservoir and move around the loop. If you don't, try unplugging the pump's fan header from the motherboard. Once the reservoir is empty, turn off the pump, and begin the filling process again. Keep doing this until your liquid coolant is flowing around the system in one continuous loop.

Now you can top off your reservoir until it's full, and we recommend you run the system for a good 24 hours to check for leaks and to make sure all the air bubbles move to your reservoir, and before plugging any hardware back in. At that point, you can top the system off once more, reconnect all your power cables, and start installing Windows.

FITTINGS OVER TUBING

If you're struggling with some of the tubing runs in your build, it might be time for you to opt for a different strategy. Although hard tubing allows you to achieve far tighter bend radii than with soft tubing, there is a limit to how tight a bend you can create. Combine that with it becoming infinitely more difficult to secure a length of bent tubing the smaller it gets on either end, and sometimes it's not worth using tubing at all.

As tubing bends, it also widens at the point where you apply the pressure to form it. No matter how tight a fit that silicon insert is, you'll inevitably have a slightly flatter tube at the point of the bend than you did before the bending process. This then makes it difficult for the compression cap to freely move over the bent area. The closer that bend is to the point at which it needs to be seated into its compression fitting, the more difficult it is to push both the cap and its o-ring on to the tube beforehand, then secure down.

You're not out of options, though, because thanks to male-to-male extension fittings, you can get around these problems. For example, in our 4K Gaming Monster build we did back at the end of 2019, the pump was located below the reservoir, underneath the power supply cover. To attach it, we used a pass-through fitting to cut through the PSU cover, followed by a male-to-male extension below, which then connected directly to the pump's inlet port. The reservoir above it was then connected by a tiny 90-degree length of bent tubing. That was particularly difficult to secure, and in hindsight and for longevity's sake, we should have just used an extension fitting to raise up a 90-degree fitting, and then connect the two fittings together with a male-to-male extension. That would reduce the risk of any unwanted bumps or knocks dislodging the tube from its o-rings and causing a leak.

Liquid Assets

What to Expect

Your build is finally finished, your loop is complete, and your system is up and running—what can you expect now? Well, first up, you'll notice a dramatic reduction in overall temperatures, most notably with the graphics card. GPUs are one of the areas that benefit the most from liquid cooling. An Nvidia RTX 2080 Super, which typically runs at 85 C under load, will likely plummet to the 60 C range, if not further. This is great for overclocking and for stock overclock features, such as GPU boost. As for your CPU, this is where your mileage is likely to vary—some processors do benefit a lot, but if we're honest, you probably won't see temperatures much better than if you were to run an AIO solution instead.

And then there's the noise, or lack thereof. We always recommend you configure your fans in the BIOS, as opposed to using desktop software. For a liquid-cooled PC, and if your loop allows it, try to aim for a fixed RPM of around 30–50 percent. You can go lower, but on the whole, that's kinda the sweet spot for a noise-to-performance ratio, and regardless of temperature, you'll have a quiet rig whether or not you're running demanding applications.

Is It Worth It?

The big question we always ask whenever we cover liquid cooling is whether it's worth it. We used that classic car analogy at the beginning, and it's something we want to come back to now. Theoretically, you don't need a fast car. You just don't. No matter how you argue, a lot of the time, that family sedan will get you where you need to be in the same amount of time as the dude tearing it up in his fully restored 57 Bel Air (even after he's invested a good $20,000 into it).

And the thing is, it's the same with liquid cooling a PC. Do you need to do it? Of course not. Will it improve performance? Yeah, considerably in some cases, and it'll definitely reduce noise, but it's not a deal-breaker. Does it really matter in the long run? Probably not. But that doesn't make it any less fun, or less skillful to do. Having that masterful piece of work sitting on your desk, that you built entirely, and that no other person in the world has, quietly working hard for you as you drop in and out of load, is so satisfying.

FULL LIQUID-COOLING KITS

Alternately, if you want to save even more cash, many manufacturers offer fully equipped kits, with everything you need to get started with your first loop. Now, we know we're highlighting EKWB a lot here, but it's just an easy example to use. The company offers two kits: a full copper setup for a 360mm radiator, waterblock, and CPU loop, which would set you back $332, or you could plump for the EK Fluid Gaming A360G aluminum kit instead, for around $240.

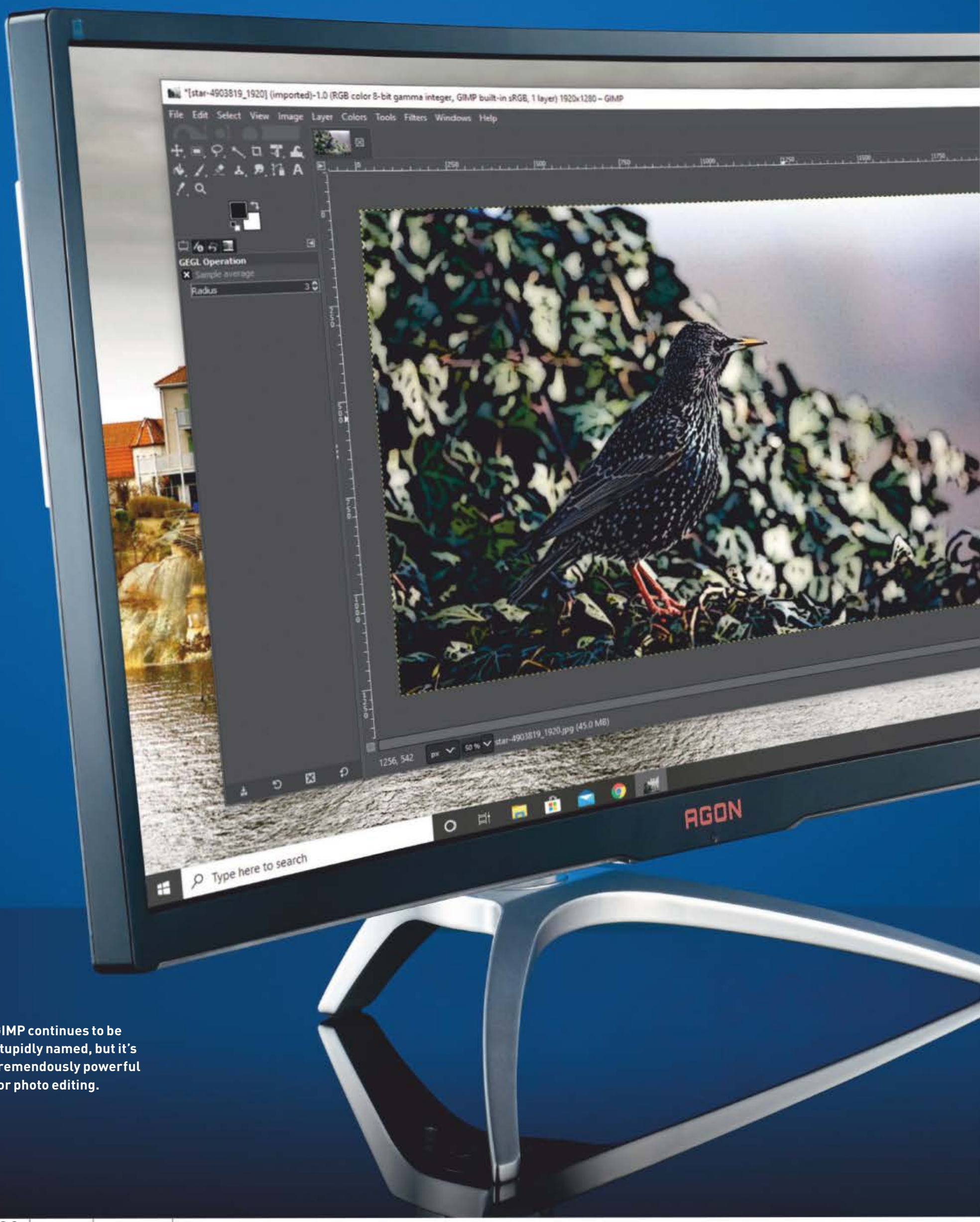
Total Cost

Can you do this on a budget? That depends on what your budget is. Liquid cooling is usually reserved for high-end systems. That's not to say you can't cool an Intel Core i5 or an Nvidia RTX 2070, but you'll see the most benefit on higher-end components, because this is usually where thermal limits come into play. At the lower end of the hardware spectrum, you're often better off investing that $400 into a more powerful processor or graphics card, depending on what you need.

With that small caveat out of the way, let's take a look at what you could do to build your own more affordable liquid-cooling loop. As an example, our theoretical system here is going to use an AMD Ryzen 7 3700X and an Nvidia GeForce RTX 2080 Super, and be housed inside the Phanteks Enthoo Evolv X chassis. So, we know we've got plenty of support for 360mm radiators, and good clearance internally to mount our hardware in a multitude of ways, and we can add to it later if need be. We would use a pump/reservoir combo to reduce the overall cost, and opt for ZMT tubing to give it a clean, industrial look.

BESPOKE LOOP

Type	Product Name	Price
CPU Block	EK-Quantum Velocity AMD Copper + Acetal	$77
GPU Block	EK-Vectgor RTX 2080 RGB Nickel + Acetal	$128
Pump/Res Combi	EK-XRES 100 DDC MX 3.1 PWM	$74
Radiator	EK-CoolStream Classic SE 360	$60
Fans	3x EK-Vardar F4-120ER 2,200rpm	$25
Fittings	8x EK-STC Classic 10/16 Black	$36
Tubing	3m EK-Tube ZMT Matte Black 15.9/9.5mm	$14
Coolant	1x EK CryoFuel Blood Red (Premix 1,000ml)	$10
Total		**$424**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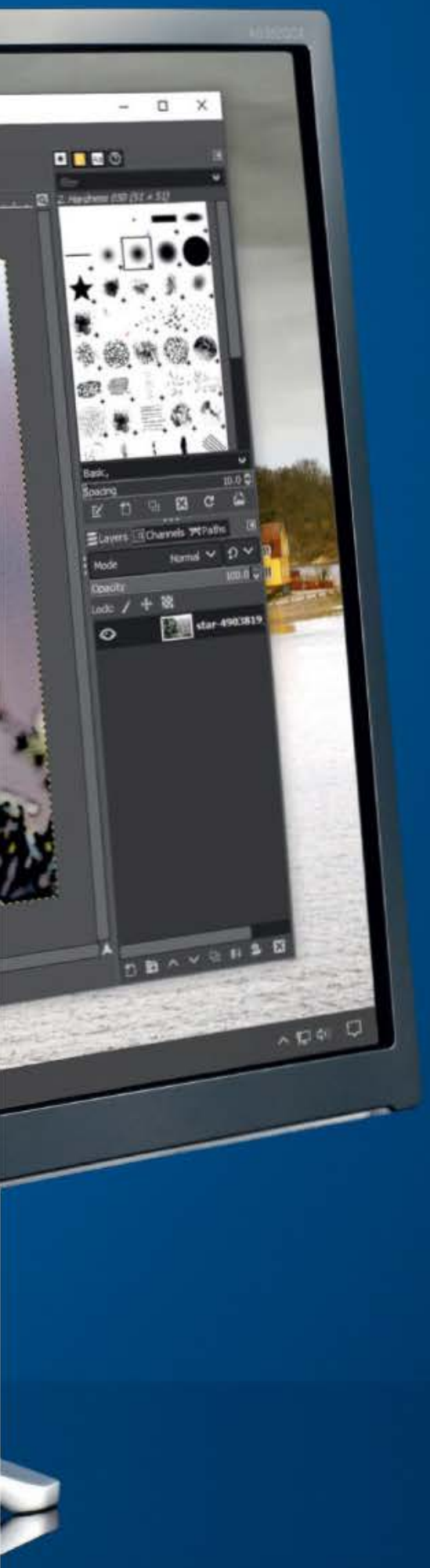
AGON

GIMP continues to be stupidly named, but it's tremendously powerful for photo editing.



THE BEST FREE SOFTWARE OF 2020

Seventy completely free apps to make you more (or less) efficient

WE KNOW WHAT you're thinking: Nobody actually wants a PC full to the brim with software. A guide to free software is one of those PC magazine tropes, and here's *Maximum PC* reaching into the well again. But wait, reader. Cool your jets and think about it. If you're looking at this guide and presuming that we're saying you have to install every little thing we've mentioned, you're doing it wrong.

This isn't about what you should have, it's about what you could have—software that could change the way you create, the way you work, and the way you manage your PC. It's about doing things better without breaking the bank. It's about software that actually deserves a place on your SSD, stuff that's so useful and well constructed that it's transcended the stigma that comes with the word "free."

The world of free software has changed significantly, because what we expect from software has changed. We have phones to thank for a lot of this—app stores have made free the default. The ever-increasing power and prominence of the web browser is another gift, because perfectly capable tools can be cooked up from JavaScript and HTML5. And the open-source community goes from strength to strength, with publishing, programming, and collaborative tools improving daily.

That said, there are some things we've sidestepped. Some software should be paid for, or it's made irrelevant by core Windows features. Antivirus is a strong example—either you rely on Windows' own tool, which is (or at least, has become) very credible indeed, or you stump up for a full version of a proper package, with the up-to-the-minute updates that come with it. A free VPN is a great idea until you realize that if you're routing your traffic through someone's servers and not paying them a single cent, they might have something else to gain from the whole thing. That's right, we're as cynical as you. But, darn it, we just love free software.

BY ALEX COX

PC TESTING AND PERFORMANCE

01 CPU-Z

Something everyone who's even tangentially interested in their PC's internals should have, CPU-Z pulls in the tiny details about your CPU, chipset, memory, and mainboard that Windows doesn't feel like sharing with you, and puts them all in one handy place. It can make a precise reading of your current clock speed for both CPU and RAM, too—great for overclockers. ***www.cpuid.com***

02 GPU-Z

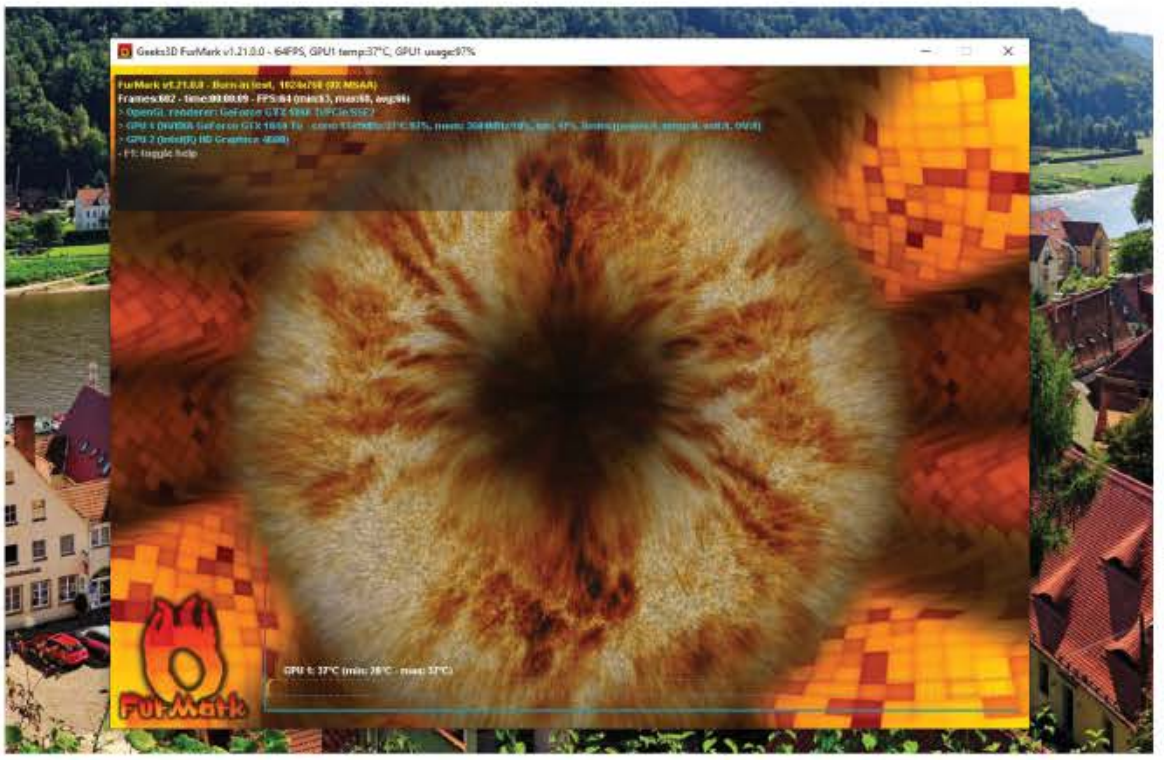
Despite the name, appearance, and incredibly similar functionality, GPU-Z has nothing to do with CPU-Z—but it does have permission from the CPU-Z author to use its title, which is nice. It's a GPU monitor, which can offer insights into both what you're running and just how well it's running, with access to a whole bunch of your graphics module's on-board sensors. ***http://techpowerup.com/gpuz/***

03 HWiNFO64

Where CPU-Z and GPU-Z are specialized snipers, HWiNFO64 is the buckshot-loaded blunderbuss of hardware monitoring. If there's a statistic out there you want to discover, it'll find it—and it's fantastic for overall system monitoring, too, with customizable graphs enabling you to track just about any metric or sensor output. ***http://hwinfo.com***

04 Rainmeter

An odd choice for the system testing section? Perhaps. But Rainmeter sneaks in because, in the course of making your desktop look incredible, you can install a plugin like CoreTemp to hook your pretty desktop graphics into the heat of your CPU, or use a skin such as sysDash to display a host of customizable stats about your system. ***http://rainmeter.net***



Be careful with FurMark—it's a really demanding and possibly damaging GPU stress test.

05 CrystalDiskInfo

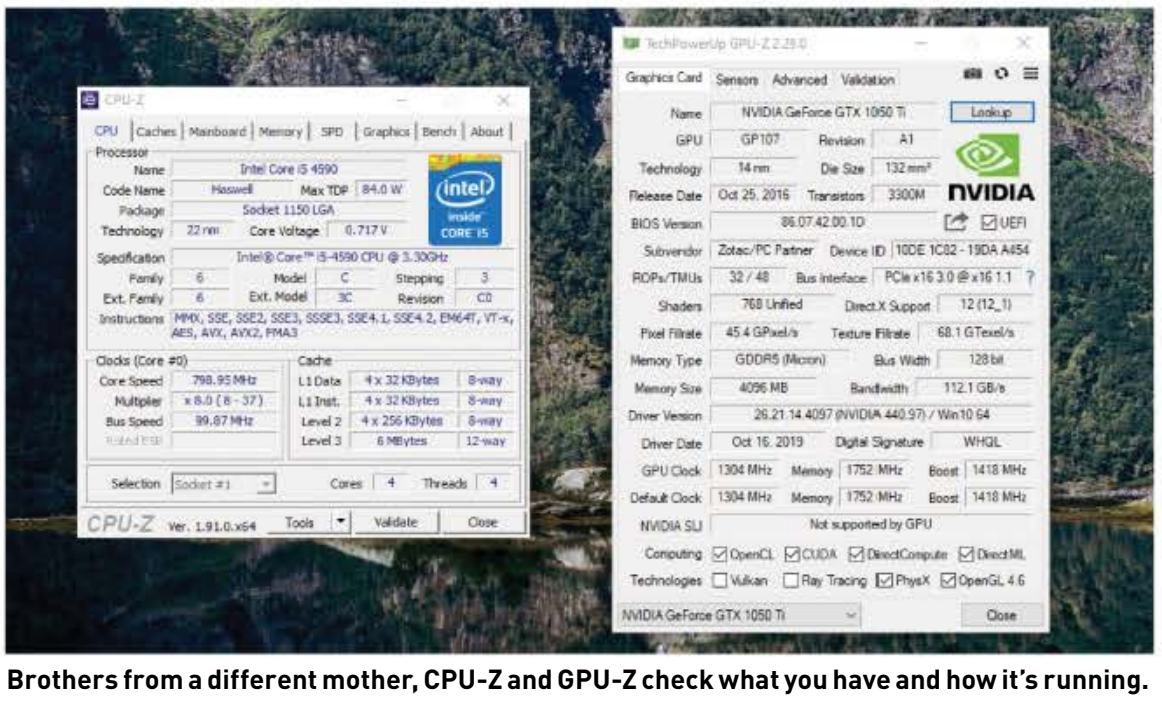
There are, for some unknown reason, three versions of this disk status monitor, but the only reason to grab the Shizuku or Kurei Kei editions are if you're desperate to have a cute manga girl next to your impossibly detailed drive statistics. See also CrystalDiskMark, which will thoroughly kick your SSD in the teeth and see what it has to say about it. ***http://crystalmark.info***

06 FurMark

A GPU benchmark that earns its place here by virtue of its stress testing and burn-in capabilities. It will absolutely hammer your GPU with its OpenGL routine, so much so that the gallery on the official website proudly includes images of hardware that went bang when it couldn't keep up. There's also an Asus ROG edition available, which tests Vulkan, too. ***http://geeks3d.com/furmark***

07 Prime95

FurMark burns in your GPU, but Prime95 is a real CPU cooker. It hunts through a bunch of possibilities to attempt to find new Mersenne prime numbers—something it's managed 16 times since 1996. It's a computationally intensive task like no other, and its torture test mode can help you diagnose issues with your processor, chipset, cache, and much more. ***http://mersenne.org***


CPU-Z
CPU | Caches | Mainboard | Memory | SPD | Graphics | Bench | About
Processor
Name Intel Core i5 4590
Code Name Haswell Max TDP 84.0 W
Package Socket 1150 LGA
Technology 22 nm Core Voltage 0.717 V
Specification Intel® Core™ i5-4590 CPU @ 3.30GHz
Family 6 Model C Stepping 3
Ext. Family 6 Ext. Model 3C Revision C0
Instructions MMX, SSE, SSE2, SSE3, SSSE3, SSE4.1, SSE4.2, EM64T, VT-x, AES, AVX, AVX2, FMA3
Clocks (Core #0)
Core Speed 798.95 MHz
Multiplier x 8.0 (8 - 37)
Bus Speed 99.87 MHz
Cache
L1 Data 4 x 32 KBytes 8-way
L1 Inst. 4 x 32 KBytes 8-way
Level 2 4 x 256 KBytes 8-way
Level 3 6 MBytes 12-way
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CPU-Z Ver. 1.91.0.x64 Tools Validate Close
TechPowerUp GPU-Z 2.29.0
Graphics Card Sensors Advanced Validation
Name NVIDIA GeForce GTX 1050 Ti Lookup
GPU GP107 Revision A1
Technology 14 nm Die Size 132 mm²
Release Date Oct 25, 2016 Transistors 3300M
BIOS Version 86.07.42.00.1D UEFI
Subvendor Zotac/PC Partner Device ID 10DE 1C82 - 19DA A454
ROPs/TMUs 32 / 48 Bus Interface PCIe x16 3.0 @ x16 1.1
Shaders 768 Unified DirectX Support 12 (12_1)
Pixel Fillrate 45.4 GPixel/s Texture Fillrate 68.1 GTexel/s
Memory Type GDDR5 (Micron) Bus Width 128 bit
Memory Size 4096 MB Bandwidth 112.1 GB/s
Driver Version 26.21.14.4097 (NVIDIA 440.97) / Win10 64
Driver Date Oct 16, 2019 Digital Signature WHQL
GPU Clock 1304 MHz Memory 1752 MHz Boost 1418 MHz
Default Clock 1304 MHz Memory 1752 MHz Boost 1418 MHz
NVIDIA SLI Not supported by GPU
Computing OpenCL CUDA DirectCompute DirectML
Technologies Vulkan Ray Tracing PhysX OpenGL 4.6
NVIDIA GeForce GTX 1050 Ti Close

Brothers from a different mother, CPU-Z and GPU-Z check what you have and how it's running.

08 Cinebench

Cinebench's visual benchmarking results make it a great tool for testing or racing one machine against another—but it's the built-in leaderboards that'll really let you know when something's up. If you're lagging behind a Core 2 Duo, either they've got some serious overclocking abilities, or there's a bottleneck on your end. ***http://maxon.net***

09 MemTest86

A very old-school tool with an old-school approach, dragged into the 21st century by its USB boot capabilities and support for just about every memory type you could throw at it. Whether you're burning in your RAM or searching it for

© CPUID.COM, GEEKS3D.COM/FURMARK

errors, there's something in its test suite for you—and it doesn't even require an installed OS. ***http://memtest86.com***

10 OCCT

Comprising a massive suite of tests, from a FurMark-esque GPU smasher to a GPU-centric memory test to a version of the LinPack benchmark used to rank supercomputers, OCCT could be the only testing app you need. Its best feature might be its PSU test, which runs CPU and GPU benchmarks simultaneously to help you determine whether there's a lack of power anywhere in your system. ***http://ocbase.com***

DESKTOP EXTRAS

16 Greenshot

Windows' screenshot abilities are getting better as time goes on (whatever you might think about Snip & Sketch) but there's nothing more convenient than Greenshot. If you're forever having to crop those dual-monitor screenshots down to size, or you're sick of launching yet another tool to get the job done, Greenshot's quick and easy system integration is a boon. ***http://getgreenshot.org***

17 EaseUS Todo Backup Free

Some might be suspicious about the Chinese origin of EaseUS Todo Backup, but there's no better desktop backup tool out there, at least at this level of usability and simplicity. Regular backups, complete drive clones, scheduled copies, partition shenanigans, whatever you need—it's all a few clicks away, and restoring is just as straightforward. ***http://easeus.com***

18 Fences 1.01

Later versions of Stardock's Fences have moved to a paid-for model, yet the lighter-in-features but nonetheless great version 1.01 remains free. It enables you to group together your desktop icons into fenced-off areas that stop them wandering around and interfering with others—you can group your games, your work apps, and so forth, for a truly tidy desktop. ***http://stardock.com***

19 Total Commander

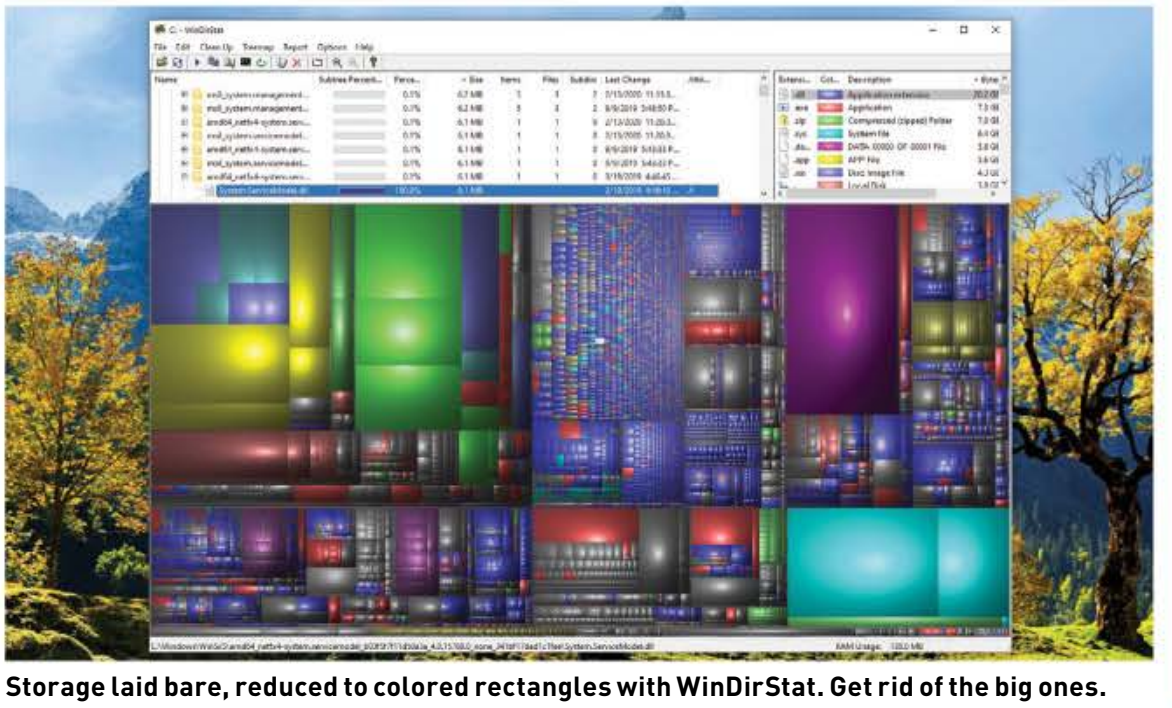
File Explorer is what we're used to, but it's a pretty awful way to manage the contents of your hard drive. Once you've switched to a hardcore tool like Total Commander, you might never go back. Its dual-pane system harkens back to the early days of file management (indeed, it's a modern clone of the Norton Commander formula) for maximum efficiency. ***http://ghisler.com***

20 WinDirStat

Let's continue sniffing at things File Explorer doesn't do well—it's really difficult to find those files on your drive that are hogging space. Particularly useful (obviously) on those machines with limited disks, WinDirStat gives you a visual look at all your files, so you can immediately pinpoint the big boys and excise them then and there. ***http://windirstat.net***

21 TidyTabs

Microsoft's long-mooted Sets feature, which groups your windows into tabbed collections, appears to have entered the testing trashcan. No problem: The execution might be a little clunky, but



© WINDIRSTAT

Storage laid bare, reduced to colored rectangles with WinDirStat. Get rid of the big ones.

IMPROVE YOUR CODING

11 UNREAL ENGINE

There's a host of game engines out there for free (Unity and Amazon's Lumberyard primary among the rivals) but Unreal Engine tops our list this time. OK, it's not technically free—you have to pay a royalty if you're using it commercially—but being able to freely get your hands on the same engine used in AAA titles is great. http://unrealengine.com

12 TRENCHBROOM 2

This editor, which turns level editing for the likes of *Quake, Hexen 2,* and, er, *Daikatana* into a snap-together breeze, might be of niche appeal, but we love it. Besides, if you build your game to accept BSP files and use its "generic" template, there's no reason you can't use it—it's the official editor for old-school modern shooter *Dusk,* after all. http://kristianduske.com/trenchbroom

13 VISUAL STUDIO COMMUNITY

Whatever you're coding, you need a good IDE. Visual Studio Community, which is free for up to five users in an organization, is a very good IDE indeed. It's modular, so you only install support for those languages you're working with, it's cloud-connected for collaboration, and (as you might expect) it's fully integrated with Git, too. http://visualstudio.microsoft.com

14 PYTHON

If you're at the beginning of your code journey, Python is the language to start with. It's simple, friendly with its syntax, and capable of some solid results, with a wide range of libraries available to help you on your way. Download one of the Windows packages—being aware that Python 2 is just as well supported as Python 3—and you get an IDE, too. http://python.org

15 ATOM

A text editor geared toward coders, Atom (made by the GitHub team) is the lightweight alternative to a full IDE, for when you just want to tinker and tweak. Naturally, it has Git integration, it's highly customizable, and if you only want to use this to type up text documents, we promise we won't tell anyone your dirty secret. http://atom.io

PLAY SOME GAMES

26 FORTNITE BATTLE ROYALE

You've already decided whether *Fortnite* is for you, and we won't try to change that, but we will say this: It's entirely free to play, and the only detriment to not paying for its optional cosmetics is the likelihood of being called a scrub by a nine-year-old with a vocabulary made up entirely of a surprising number of vile slurs. http://epicgames.com

27 MAGIC THE GATHERING: ARENA

Call us disingenuous all you like, because *MTG* is, like *Hearthstone,* a game you need to invest in to do well. But this client easily replaces the awful *Magic Online* as our favorite way to smash monsters together. Find a friend, grab one of the prebuilt freebie decks, and show them who's the spiciest planeswalker. http://magic.wizards.com

28 DWARF FORTRESS

***Rimworld* may have taken the formula and run with it, but you can't beat the insanity of an intricately detailed dwarven settlement, with all the foibles of the dwarves within. Will they get offended by a horrible miasma, throw themselves off a ledge in a fit of madness, hide themselves away to create a masterwork when they should be chopping trees, or something crazier?** http://bay12games.com

29 GWENT

Arguably the best thing about Geralt's sword-swinging adventures through *The Witcher III* was sitting down with random folk for a good old game of *Gwent*—and the spin-off game, which puts you in the Butcher of Blaviken's ample shoes, is just as rewarding. It's spawned its own esports scene, and is astonishingly moreish. http://playgwent.com

30 PATH OF EXILE

The leading multiplayer *Diablo*-like *(Diablike?)* out there today, *PoE* is perfectly ransackable without forcing you to pay for trinkets and armors, and it's constantly growing with new expansions and upgrades. Beware, though: This game will get under your skin and stay there, and many people take it very seriously indeed. http://pathofexile.com

Click until you can click no more—*Path of Exile* is a compelling game.

TidyTabs pulls off the same trick. You can mash together a File Explorer window, Microsoft Word, your web browser, whatever, all in one draggable, resizable unit. ***http://nurgo-software.com***

22 Ninite

Setting up a new PC with apps is a tedious and click-heavy process unless you take advantage of something like Ninite, which pulls down your choice of programs and installs them fuss-free. That's only one of its primary functions; once you've done your multiple installation, you can run it again to update those apps seamlessly from one place. ***http://ninite.com***

23 Wushowhide

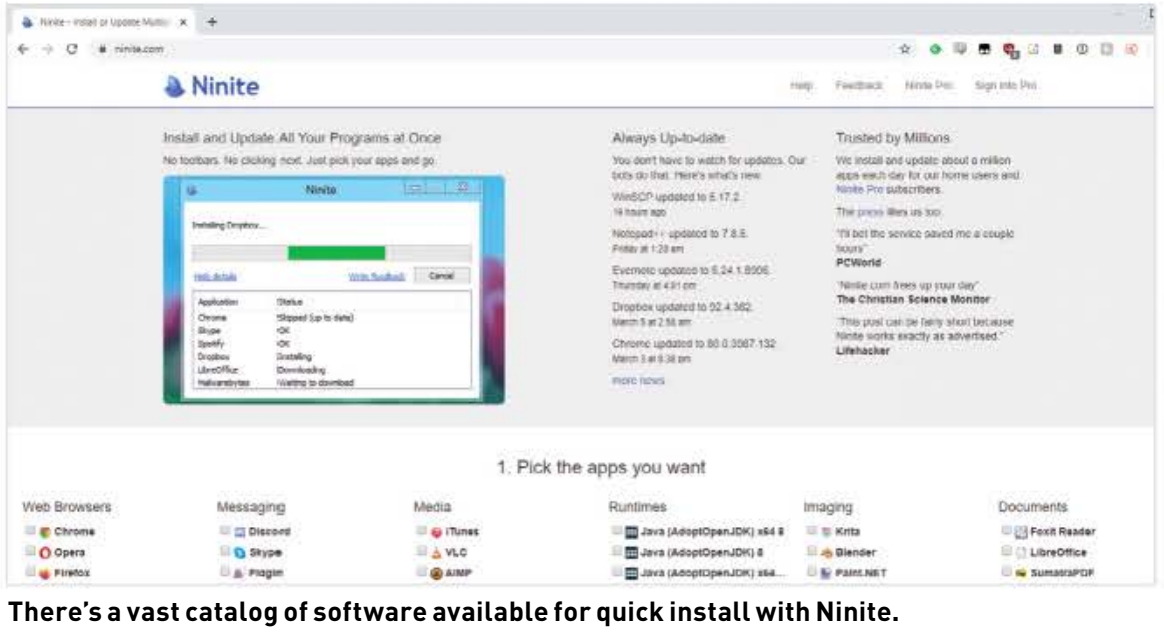
More than once in the past few years, Microsoft has pushed out a bad Windows update that caused chaos. If you're determined to keep your machine running on a certain patch—and if you're doing something mission-critical, this might be a good idea—you can use Microsoft's own Wushowhide tool to hide Windows Updates or wobbly device drivers from the auto-updater's prying eyes. ***http://bit.ly/3clA1Yo***

24 TestDisk

Don't be fooled by the name. While TestDisk is capable of testing disks, it's much more adept at pulling data from drives that are about to click their last, or those writable optical disks that have started to rot with age. Sure, it's not exactly pretty, and it's rarely quick to do the job, but TestDisk is an absolute essential for data recovery. ***http://cgsecurity.org***

25 Graser

If you don't want that data recovered ever, you probably already know that simply deleting a file isn't enough—it only really deletes the reference to the file, and it won't be gone until it's overwritten by something else. Eraser positively shreds that data, overwriting it with zeroes and ones repeatedly to ensure no trace of it is left. ***http://eraser.heidi.ie***



There's a vast catalog of software available for quick install with Ninite.

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CREATIVITY

31 Cakewalk

Here's the story: Cakewalk started on DOS in 1987, spawned high-level digital audio workstation SONAR, its parent company got bought by Gibson, which gave up on the software, then BandLab snapped up the license, renamed SONAR back to Cakewalk, restarted development, and threw the whole thing online for free. It's a fantastic pro-level DAW worthy of all those commas. ***http://bandlab.com***

32 Pro Tools First

We wouldn't use Cakewalk to record a podcast, but Pro Tools First, which is a cut-down tool based on the high-end audio workstation used in professional studios, is the perfect choice. It can pull in four audio inputs at once, which is great for separating individual mics, and the First version includes 23 high-end effects. ***http://avid.com***

33 Audacity

For simplistic audio futzing, or cleaning up less-than-great recordings, Audacity's straightforward interface is just the thing—particularly given the greater complexity of full-on workstation packages. It's great for swift cuts and crops, snipping out coughs or hesitations, or just recording something simple and quick. ***http://audacityteam.org***

34 GIMP

It wouldn't be a free software list without GIMP. That's not us being lazy (honest), but evidence of its brilliance—for a community-developed image editor, this is as good as you'll find. It's approaching the abilities of Adobe Photoshop, and while it might never reach those heady heights, it's also not going to cost you $500 a year to use it. ***http://gimp.org***

35 Paint.NET

Microsoft seems determined to kill its own creative apps, but Paint.NET —which takes the Microsoft Paint formula and adds a host of power and functionality—remains determined to keep that simple dream alive. It might not have all the features and plugins that GIMP waves around, but it has enough to pull off a quick job. ***http://getpaint.net***

36 Inkscape

Do you frequently edit vector graphics? You don't? Of course you don't. But if you ever do need to create a scalable illustration, the extra learning curve of Inkscape is probably worth the vast difference in price between this and Adobe Illustrator. Even if you don't think you need it, Inkscape's abilities as a planning and sketching tool are peerless. ***http://inkscape.org***

Cakewalk incorporates its own software instruments and works with VST synths, too.

37 Scribus

We admit we're still waiting for someone to release a truly awesome free desktop publishing package, but if you've had it with Microsoft Word's inability to lay out a page properly, this well-seasoned DTP veteran will come in handy. Nearly 20 years down the line, it works perfectly well, but it's still a little rough around the edges. ***http://scribus.net***

38 DaVinci Resolve

Another one with a steep barrier to entry, but don't let that stop you: DaVinci Resolve is a super-high-end video editor, inexplicably offered to you for free. It's adept at cutting and slicing, particularly with the new features in version 16, but it's primarily a grading tool—turning mixed footage into one consistent and colorful whole is a satisfying experience indeed. ***http://blackmagicdesign.com***

39 Blender

Once (oddly) touted as a game engine, Blender has settled into its skin as a full 3D suite, with all the tools you need to construct models, and plenty of tech in there to allow you to rig, animate, and motion-track them, too. Its rendering engine is super-neat, and Blender can even act as a video editor and 2D animation suite in a pinch. ***http://blender.org***

40 Daz 3D

Used by professionals but easy enough for anyone to get involved with, Daz 3D is another 3D renderer that gives you access to a whole lot of intricate detail and physics features. As far as we can see, it makes its money from asset sales, but as Daz also publishes the Hexagon modeling tool (also free), it's plausible to run a cost-free pipeline. ***http://daz3d.com***

SUPERCHARGE YOUR STREAMING

41 STREAMLABS OBS

We've nothing against standard OBS but our preferred stream tool is Streamlabs' variant. It's neater, it's packed with handy filters, and it makes both configuring a stream layout and controlling your inputs and outputs straightforward. There's even a selection of (somewhat cheesy) templates to choose from to get you started. http://streamlabs.com

42 LIGHTSTREAM STUDIO

If you want to quickly stream from a new computer, or don't want the hassle of installing anything, Lightstream is a very cool solution—it runs entirely within a web browser, and allows far more customization over what you're showing than the rudimentary browser tools offered by YouTube or Facebook. There's a 720p limit and a watermark on the free tier, though. http://golightstream.com

43 DISCORD

Nothing builds a community like Discord, so whether you want to give viewers somewhere to go to bad-mouth you or you want to get other voices on your stream, Discord is an efficient way to do it. It's supplanted things like Skype and Slack for us; it's perfect even if you just want to set up a meme-heavy chat with buddies. http://discordapp.com

44 HEXCHAT

You'll know Twitch chat as a rotten hellscape of awful icons and incessant shouting, but it's still useful for streamers who want to see who's backseating and who needs banning. HexChat, spiritual successor to mIRC, allows you view Twitch chat differently, to filter out the noise and see who's actually watching. http://hexchat.github.io

45 TWITCH TRACKER

Just how well has your stream performed? If you use Streamlabs OBS, you get a nice little report at the end of each session, and Twitch itself offers some insights, but for the rest of us, Twitch Tracker is a very handy tool. It's not restricted to just your own streams, either; you can use it to see what's hot, who's performing well, and a lot more besides. http://twitchtracker.com

© CAKEWALK

DO DEEP-DIVE TWEAKING

46 AUTORUNS

Booting up a Windows PC has always been a bit of a gamble. If there's some program that's going to take its sweet time getting going, causing your machine to respond like it's drowned in syrup, Autoruns does a good job of stopping it. It allows you to get far more in-depth than Task Manager, as you can kill individual processes and Windows components too. http://sysinternals.com

47 PROCESS EXPLORER

Task Manager is not a bad tool, but more detail is always good. Process Explorer gives you that; it allows you to break down exactly which DLLs and sub-processes those rogue programs are running, and it lets you act on them. Results are dependent on your knowledge and foolhardiness; use at your own risk. http://sysinternals.com

48 LOCKHUNTER

Malware (or just badly coded programs) can sometimes lock files on your system to stop them from being deleted. If you're suffering from such an issue, LockHunter does just what its name implies: It works out which process is stopping the deletion, and either allows you to kill the offending process or bypasses the lock to throw that file in your recycling bin. http://lockhunter.com

49 SHELLEXVIEW

Shell extensions extend your Windows PC's right-click capabilities. That's great until it isn't; if you've got a right-click menu clogged up with a bunch of useless links to software you barely use, it could be time for a tidy. ShellExView shows you exactly which extensions you have installed, and allows you to disable and enable them at will. http://nirsoft.net

50 EVERYTHING

Oh Windows search, how poor you still are for some unknown reason. Everything lists absolutely everything on your system, every single file and folder, and filters it down as you type. So whether you're looking for a filename (quick) or the contents of a text file (far slower), it's a much better choice than that box on your taskbar. http://voidtools.com

PRODUCTIVITY

51 Brave Browser

One of the fastest rising browsers, Brave uses Chromium to render pages, but that's where its similarities to Chrome end. It's focused on privacy, from blocking ads and trackers to integrating a Tor-routed stealth mode. And if you rightly feel guilty about taking revenue away from sites, you can anonymously chip a little into the pot for them, too. ***http://brave.com***

52 Rambox

In the past, we've recommended Franz for your multiple-chats-in-one-place needs, but Rambox seems to have superseded it. Not only is it a great way to communicate with those who refuse to move off legacy chat platforms, but it's a clever one-stop shop for a whole raft of apps—including those you add yourself, if you're clever enough. ***http://rambox.pro***

53 LibreOffice

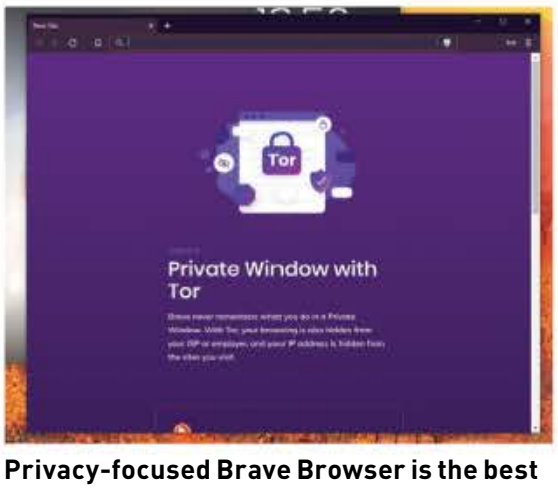
LibreOffice, OpenOffice, Calligra, MaximumOffice2K—they are all, with exception of that last one, solid free office packages based on the same codebase. But LibreOffice has settled down as the package with the strongest developer support, and we say it's the one to use if you want a Microsoft Office-esque experience for free. ***http://libreoffice.org***

54 Google Docs

Don't want to work on the desktop? Google's online office suite is functional enough, and it's excellent for collaborative working. Each document gets its own chat room, and you can see what others are doing to a document in real time, including the placement of their cursor. Just don't use it to annoy your colleagues, eh? ***http://docs.google.com***

55 Todoist

The further we get in this feature, the more it seems we're giving Microsoft a hard time, but here's the truth: Wunderlist used to be great, then Microsoft bought it, ignored it, started its own competing To-do app, and made it not quite as good. Thankfully, Todoist is around to provide a viable alternative for listing all those tasks you should have done yesterday. ***http://todoist.com***



Privacy-focused Brave Browser is the best way to browse the web with confidence.

56 Notepad++

This is one of those must-installs. It's great for code, it's great for making notes, it's great for viewing text documents quickly, and it's super-optimized to boot. The developer claims that last point is because he's "trying to reduce the world carbon dioxide emissions"—a noble, tiny goal. ***http://notepad-plus-plus.org***

57 IrfanView

For viewing, converting, batch processing, and making tweaks to images, IrfanView is about as good as it gets. It's not really a paint package or Photoshop alternative, but it's damn convenient, with a shell extension to put its most common features in your right-click menu and a host of plugins to extend its abilities. ***http://irfanview.com***

58 FocusWriter

As *Maximum PC's* beleaguered editors will tell you, some people struggle to focus on getting their work done. FocusWriter is the perfect antidote to procrastination, cutting out distractions, hiding away the menus, and giving you a blank page to fill with lovely words. That and some optional typewriter sound effects, which we recommend you leave switched off. ***http://gottcode.org***

59 KeePass Password Safe

Security isn't an afterthought, and you should have a password manager. You're free to trust your precious logins to an online service like LastPass, and indeed that's the most convenient way to manage that data over multiple machines. But if you'd rather your credentials stayed out of the cloud, the open-source KeePass is the best choice. ***http://keepass.info***

60 Malwarebytes

While we encourage staying clear of free antivirus packages, Malwarebytes' bad-stuff-sniffing abilities convince us this adjacent package is a worthy install. If you suspect there's something up, running it gives you an overview of anything worrying on your system. ***http://malwarebytes.com***

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TAKING IT EASY

61 Plex

You could opt for any one of a number of standard media players—VLC, PotPlayer, Media Player Classic, et al—but we don't understand why you would when setting up a Plex server is so easy. It gives you access to your media in your browser, and lets you stream it wherever you might want to watch it, with automatic transcoding depending on network quality. ***http://plex.tv***

62 Subsonic

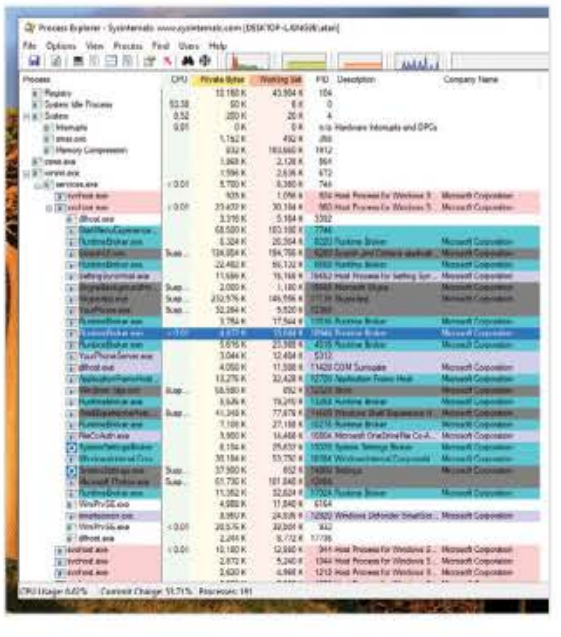
Today's streaming services mean this might have had its day in the sun already, but Subsonic is an audio-focused network player perfect for those keeping their music collection on a NAS. It includes a bunch of handy server features such as podcast catching and, indeed, conversion of playlists into downloadable podcasts—and you can share your library with others, too. ***http://subsonic.org***

63 Stellarium

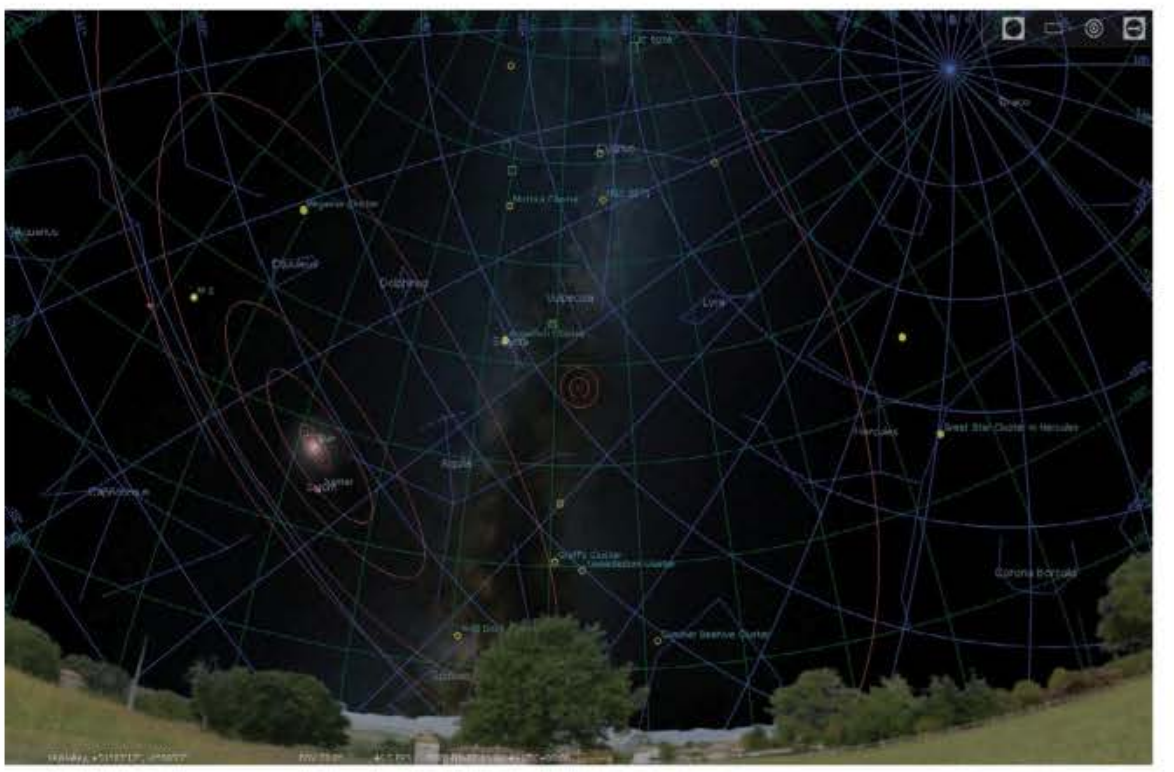
Take a trip through the stars from your desktop with the excellent Stellarium, an interactive planetarium that can be extended to include a catalog of some 170 million stars. There are logging features for those with scopes pointed at the sky, and a web version at http://stellarium-web.org, but it's the desktop client that's the most rewarding and fun. ***http://stellarium.org***

64 Google Earth VR

The greatest non-gaming use of VR there is, Google Earth VR can turn you from a towering mountain giant standing above Mount Everest to an insignificant human teetering on the edge of a skyscraper, and everything else between. Extra points for its peripheral vision fuzzing, which makes jumping from place to place a much less sickening experience. ***http://vr.google.com/earth***



Tell us, Process Explorer, what does Skype want with 250MB RAM?



Open your eyes, look up to the skies, and see what's up there. Stellarium is fascinating.

65 DOSBox

You shelled out a lot for that PC, didn't you? Such a shame. What you really need is an early '90s era DOS machine capable of playing *Space Quest* and *Commander Keen,* and DOSBox is all too willing to provide it. An x86 emulator for your x86 machine, it's easy to configure exactly to your liking—and if that means it pretends to be a 286 with CGA graphics, so be it. ***http://dosbox.com***

66 LaunchBox

How many launchers for games do you need? If you're sick of hunting through Steam, Origin, Uplay, BNet, the Epic Games Launcher, et al for that one game you want to play, LaunchBox collects everything together in one attractive app. You can also use it to neatly launch emulated games, meaning it's great if you're setting up a PC for a younger user. ***http://launchbox-app.com***

67 RetroArch

An emulator for just about everything, RetroArch cleverly makes use of what it calls "cores"—basically mini apps that contain the virtual guts of old computers and consoles—but retains your configuration between them. No need to remap controllers or move from emulator to emulator, just run your entirely legal and legitimate ROM file, and you're away. ***http://retroarch.com***

68 F.Lux

The scientific benefits of lowering the blue light output from your monitor are, at present, being hotly contested, but don't let that stop you from reducing eye strain in those evening hours. F.Lux can go further than Windows' built-in Night Light mode, going as warm as 800K, and it can even integrate with Philips Hue lights for a double dose of evening glow. ***http://justgetflux.com***

69 Duolingo

Modern language-learning is nothing like it was at school. Now you get coached by a weird little green owl, and even your earliest French lessons, funnily enough, give a strange prominence to the word *"chouette."* A brilliant thing, completely free, Duolingo turns vocabulary building into a game—and one you can play against your friends, too. ***http://duolingo.com***

70 ColorPic

Lest you accuse us of running out of ideas 70 applications in, here's a program that gives you the ability to pick out the color of absolutely any pixel on your screen. Want to do some CSS in Discord purple? Go for it. Want to tell what color your cat really is? Eyedrop that sucker up. One of those things you'll never know you need until you need it—but when you need it, you'll be glad to have it. ***http://iconico.com***

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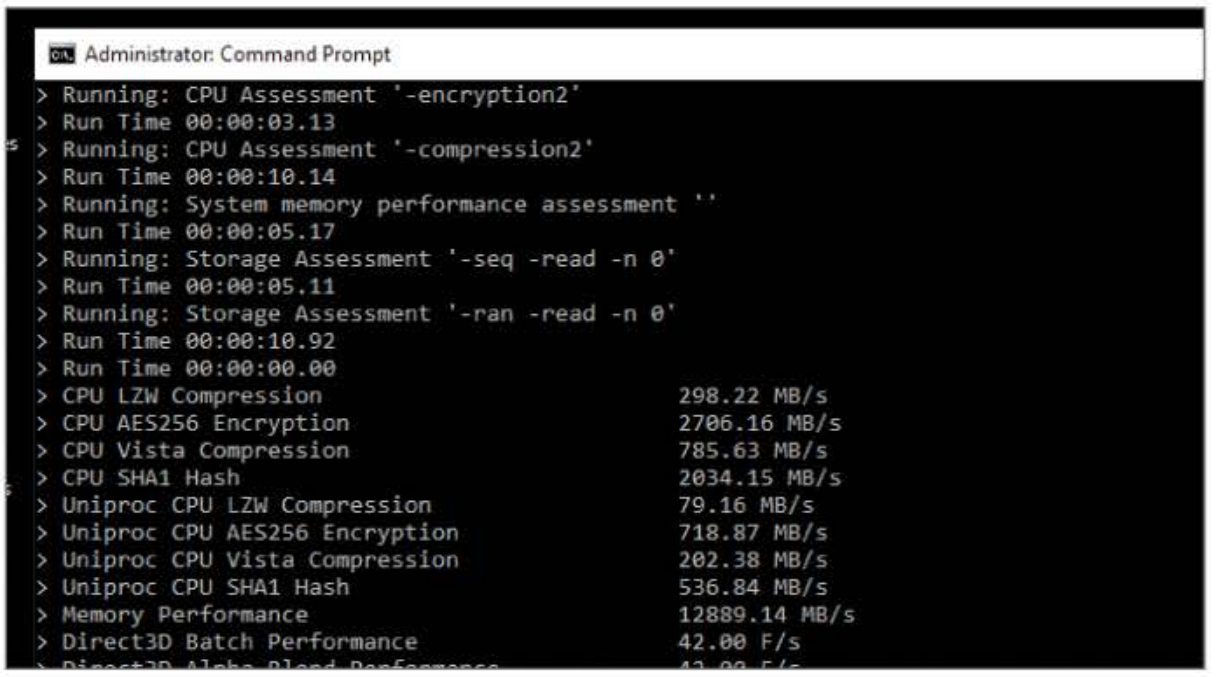
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH


Administrator: Command Prompt
> Running: CPU Assessment '-encryption2'
> Run Time 00:00:03.13
> Running: CPU Assessment '-compression2'
> Run Time 00:00:10.14
> Running: System memory performance assessment ''
> Run Time 00:00:05.17
> Running: Storage Assessment '-seq -read -n 0'
> Run Time 00:00:05.11
> Running: Storage Assessment '-ran -read -n 0'
> Run Time 00:00:10.92
> Run Time 00:00:00.00
> CPU LZW Compression 298.22 MB/s
> CPU AES256 Encryption 2706.16 MB/s
> CPU Vista Compression 785.63 MB/s
> CPU SHA1 Hash 2034.15 MB/s
> Uniproc CPU LZW Compression 79.16 MB/s
> Uniproc CPU AES256 Encryption 718.87 MB/s
> Uniproc CPU Vista Compression 202.38 MB/s
> Uniproc CPU SHA1 Hash 536.84 MB/s
> Memory Performance 12889.14 MB/s
> Direct3D Batch Performance 42.00 F/s

CHECK OUT YOUR SYSTEM WITH WINSAT

Windows has had a neat little system-testing tool built in ever since Vista, and it's called WinSat. Run the Command Prompt as an administrator, then punch in "winsat formal" to run a standard system test. Different commands enable you to check live stats, such as memory performance using "winsat mem"; type "winsat -help" for a detailed breakdown of the options available, such as specific CPU tests.

MAKE – USE – CREATE

46 Set up a dual-boot Elementary distribution

52 Enable G-Sync on a FreeSync monitor

56 How to build your own $3,333 Pink Pariah

© MICROSOFT

CHRISTIAN GUYTON
STAFF WRITER

ALL SYSTEMS ARE GO

Exploring beyond the thoroughly charted waters of Windows 10 can be daunting, but if you're building a system on a budget, it can also be a lifesaver. Rather than diving into the muddier waters of unactivated Windows rips and drive transplants, free operating systems such as Ermine and Elementary OS (see page 56) are a relatively underpopulated desert island surrounded by a crystal-clear ocean. Just watch out for sharks (read: bugs).

Linux-based OSes, such as Ubuntu's suite, are cheap or free, thanks to open-source licensing, and have benefits over Windows or MacOS. Yes, Win 10 comes with a guarantee of stability and handy tools, but an open-source OS allows for more customization and cuts a lot of the flab.

In fact, if I wasn't a dedicated gamer, I'd consider making the switch to an Ubuntu-based OS on my home rig. Getting platforms like Steam running on Linux isn't too difficult, but the last time I tried to play *The Division 2* on an Ubuntu build, I got a cluster headache. The fact is that Win 10 is the best OS for gaming; maybe one day someone will come along with an awesome gaming-oriented Linux OS that blows everyone away, but right now, I'll settle for paying Microsoft for my Windows license.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

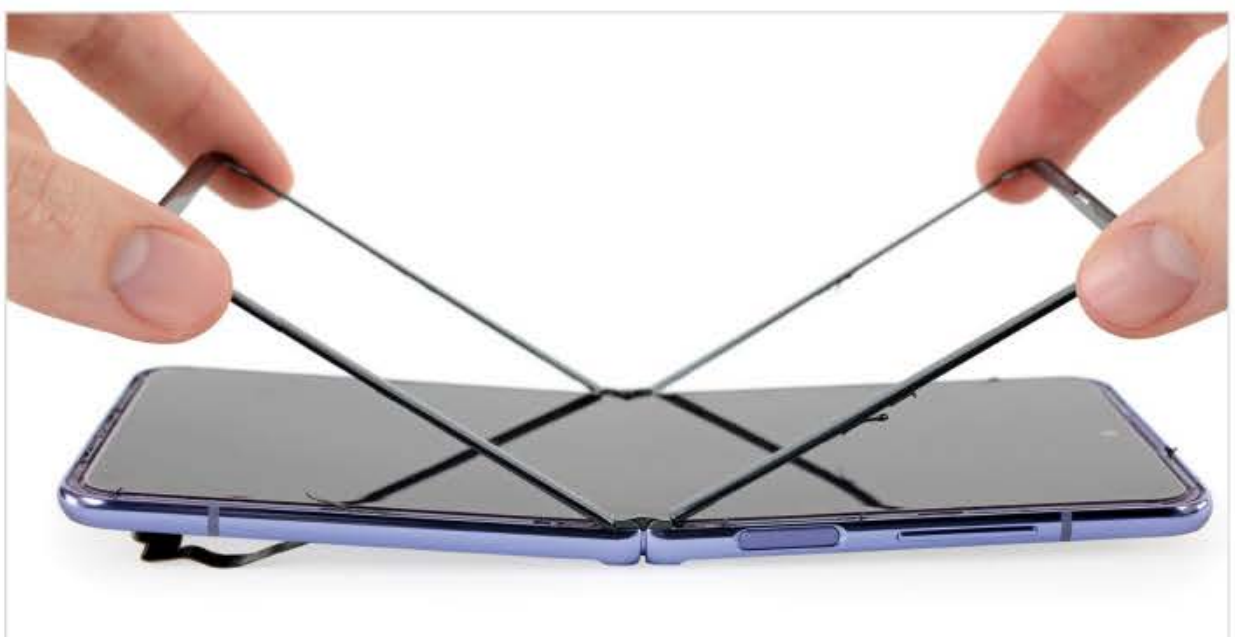
THIS MONTH WE DISSECT...

Samsung Galaxy Z Flip

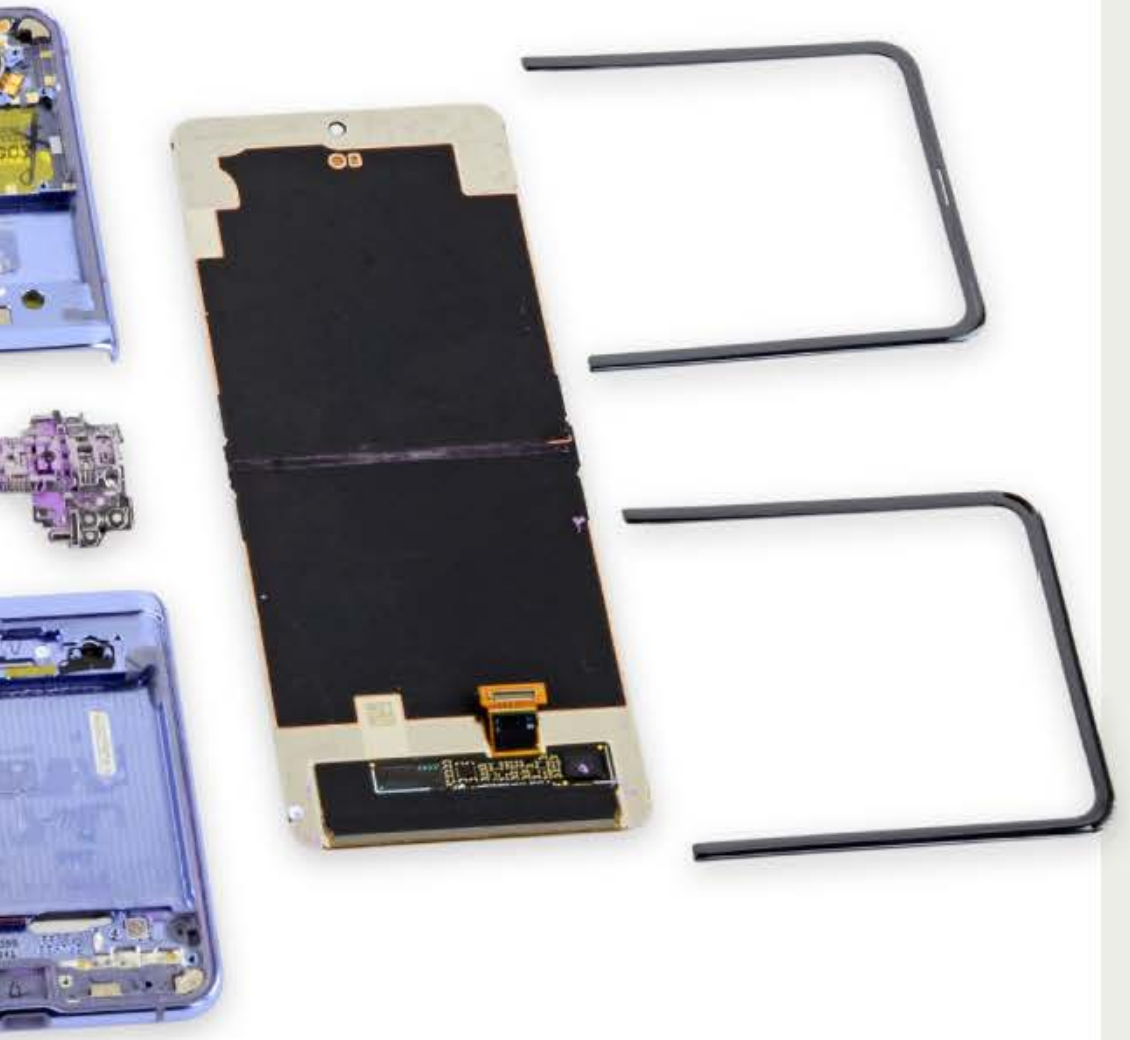
Lock Z-foils in attack position! These glued-down plastic bezels guard the primary display.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.



This month, we're taking a knife to the Samsung Galaxy Z Flip.



Alcohol and careful prying are required to fetch the batteries out.

BACKGROUND

Samsung proudly touted its hot new Galaxy Z Flip's folding glass display and the "layer of fibers" built into its hinge at the company's Unpacked event. We managed to get hold of one, and now it's time to put it to work—for a teardown.

MAJOR TECH SPECS

- 6.7-inch foldable ultra-thin-glass AMOLED Display, 21.9:9 aspect ratio, 2636x1080 pixels (425ppi)
- 2.95GHz, 64-bit, octa-core Qualcomm Snapdragon 855+ SoC
- 8GB of RAM and 256GB of internal storage
- 3,300mAh of battery power in two cells
- Two rear cameras, both 12MP, one *f*/1.8 wide-angle and one *f*/2.2 ultra-wide; one 10 MP *f*/2.4 selfie cam
- "Sweeper technology" made up of a layer of fibers inside the "Hideaway Hinge" to repel dirt and dust

KEY FINDINGS

- Open the Z Flip, and you'll spot the crease in the display. That glass sure creases like plastic; looks like it scratches like plastic, too! It's not as durable as Gorilla Glass.
- Samsung says that the Z Flip's hinge-sweeping "brushes" use nylon fibers to repel dust, but when you turn it on, you get a litany of warnings. So, we introduce our Flip to some bright purple dust. After a few seconds of heavy dust exposure, opening the phone results in horrible popping noises and a hinge that's frozen solid.
- We remove both rear covers and spot purple dust peeking out from under the wireless charging coil. Peeling up the coil reveals a powdery reminder that you should believe warning text more than marketing hype.
- The Flip packs a dense, double-stacked motherboard. We first saw this space-saving technology in the iPhone X. It makes life harder for board repair experts, but also packs a lot of chips into a tiny space.
- We remove the two batteries. The larger one is limited to a typical capacity of 2,370mAh and 9.15Wh, with the smaller battery sporting 930mAh and 3.59Wh. All that adds up to 12.74Wh, about on par for flagship smartphones. Stubborn glue secures both batteries, as per usual.
- Mild heat and careful prying gradually release the display from its frame. The glue is forgiving, but it's far too easy to accidentally separate the display's layers. The top layer is plastic, which sort of defeats the purpose of a "glass" display. You can tell the middle layer is glass because of the way it shatters when we poke it. Oops.
- Peeling back the hinge's "protective" tape reveals the highest concentration of purple dust. Looks like the tape kept the dust away from the display but held it in the hinge.
- Repairability: 2 out of 10 (10 is easiest to repair). A single Phillips driver takes care of all the screws. Many components are modular and can be replaced independently. Glued-down glass panels are an unnecessary barrier to entry for repairs, especially given the phone's lack of ingress protection. Battery replacements are possible, but unnecessarily difficult due to poorly routed cables and the lack of stretch-release adhesive. The components involved in the folding process are likely to wear over time, necessitating eventual replacement.

Set Up a Dual-Boot Elementary Distro

YOU'LL NEED THIS

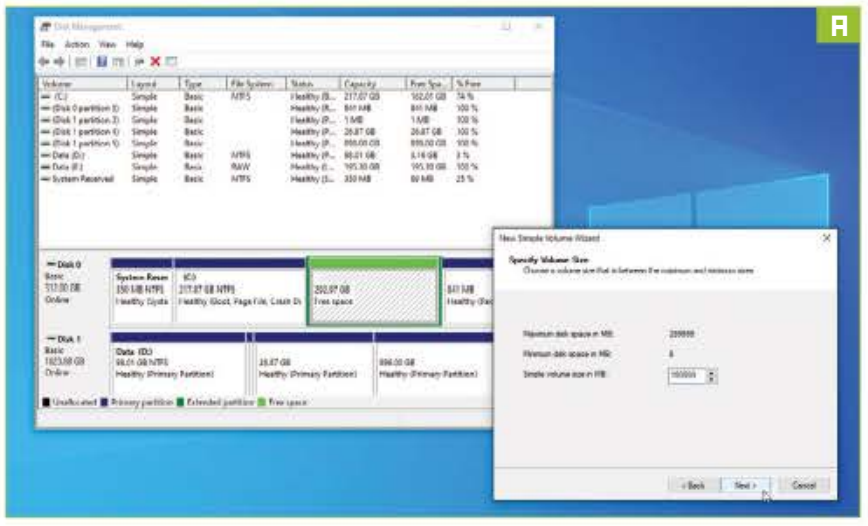
ELEMENTARY OS
Get this Ubuntu-based version of Linux from https://elementary.io.

HARDWARE SETUP
Enough hard drive space for a shared data partition and a minimum of 50GB for Elementary.

IF YOU'RE LOOKING FOR A REASON to switch to Linux, Elementary OS is a compelling distro to try. It'll appeal to both Mac and Windows switchers looking for a slick, intuitive desktop. It's built on rock-solid foundations, forked from Ubuntu 18.04 LTS, so you can leverage your existing Linux expertise and embrace it in the knowledge that anything that works with Ubuntu should also work with Elementary.

The latest version of Elementary—version 5.1, codenamed Hera—is the best yet. In this tutorial, we're going to show you how to install it alongside your existing OS—whether Windows or macOS. You'll set up a shared data partition, giving you access to your key docs, photos, and other files from both OSes. We'll give you a quick tour of the basics, get everything working correctly, and introduce you to its core elements.

Before diving in, though, we recommend taking Elementary OS for a test drive, which can be done one of two ways: Either set up a virtual machine for an extended trial, or choose the "Try" option from the installation media, to give the user interface a test run. Once you're happy you'd like to install it permanently, read on. **–NICK PEERS**



1 SET UP SHARED DATA DRIVE

First things first: If you're going to share a data folder between Elementary and your existing OS, you need to create a dedicated data drive. This can be a separate (preferably internal) hard drive, or you can partition your main system drive if it's big enough—typically 250GB or larger. 250GB would give your existing OS and data partitions 100GB each, leaving 50GB free space as a comfortable minimum for Elementary.

›› We'll assume you know the basics of partitioning—taking the example above, Windows users should shrink their system drive by 150GB, then create a 100GB NTFS partition for their data [**Image A**], leaving 50GB free. Mac users can't leave any empty space, so start by creating a 100GB data partition using HFS+ (Mac OS Extended—no journaling). Once done, create a further 50GB partition as a placeholder for Elementary—make this FAT for easy identification later.

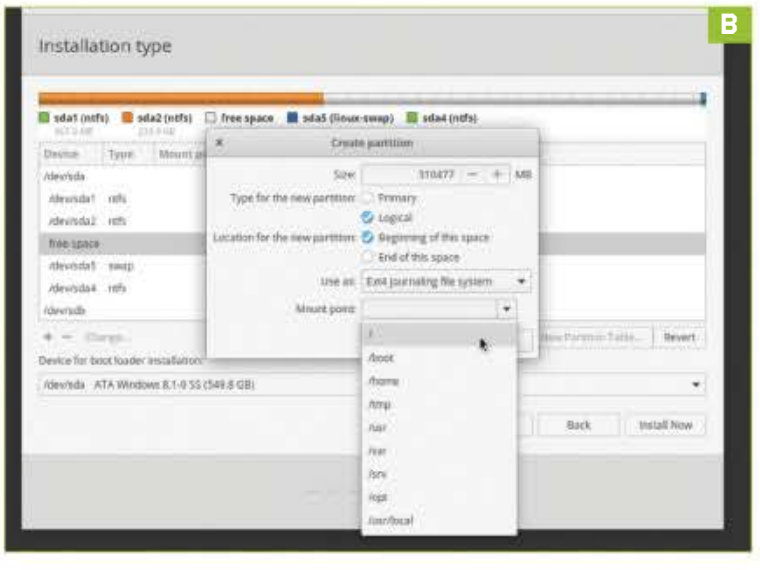
›› Once you've created your data partition, you need to move your personal folders to it. Windows users can simply move each personal folder in turn via File Explorer: Right-click the folder and choose "Properties → Location tab," then select a folder on your newly created partition, moving the data across when prompted, so Windows knows where to look.

›› Mac users can choose to relocate their entire user folder to the new drive—copy it across, then open "System Preferences → Users & Groups." Click the lock to make changes, then create a new Administrator "rescue" account—this ensures you can boot into macOS if anything happens to your data drive. Once done, right-click your current user account entry, and choose "Advanced Options." Click "Choose" next to "Home directory" and point this to your newly copied folder on your data drive. Once selected, reboot and check everything's now pointing to the data drive. Once you're happy it's working as expected, you can delete the original user folder on your startup volume.

2 CREATE BOOTABLE MEDIA AND START INSTALL

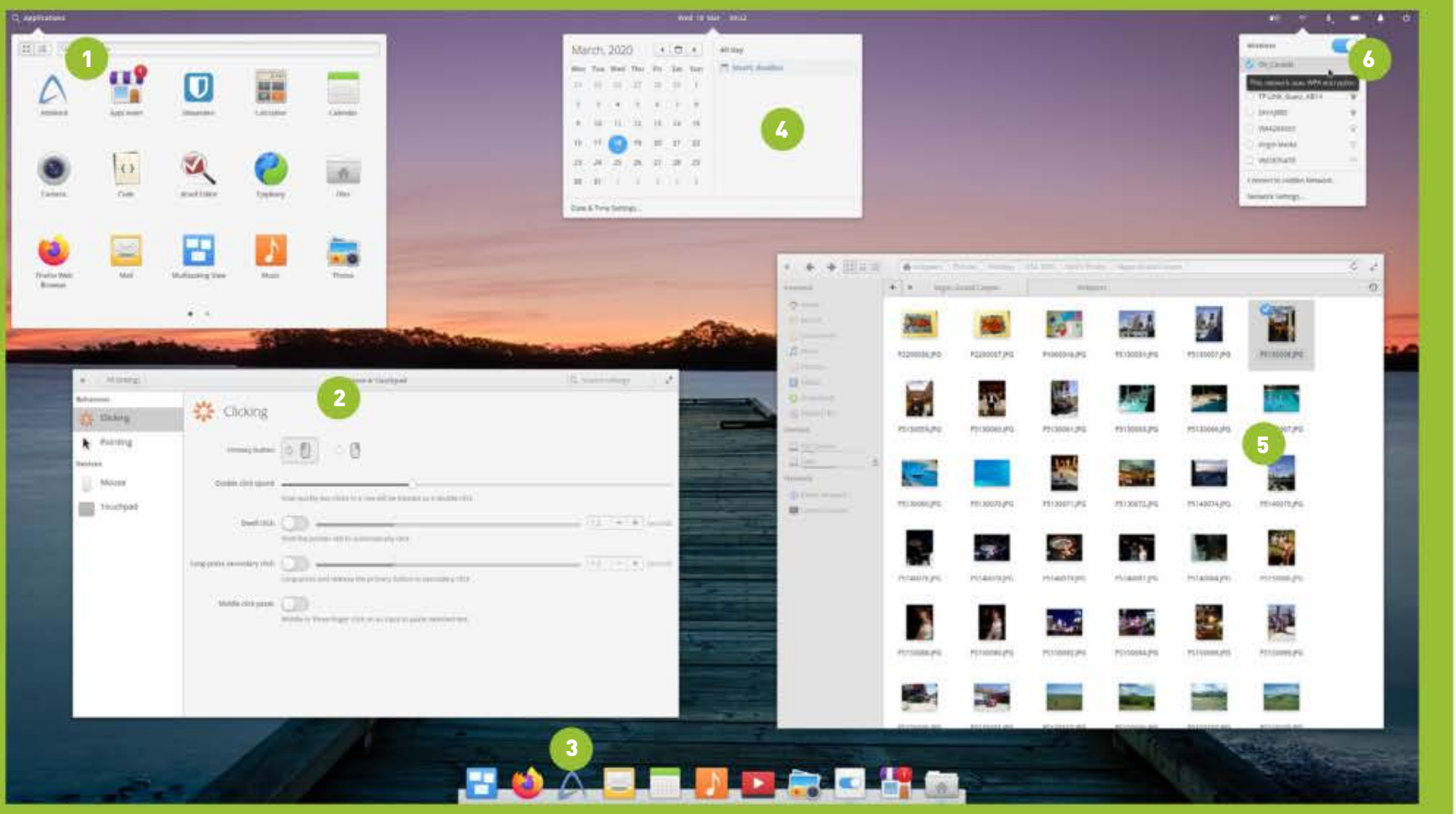
Go to https://elementary.io—type 0 into the "Custom" box to download Elementary OS for free. Choose the "Download" button when prompted. After saving the ISO file to your "Downloads" folder, use a tool such as Balena Etcher (www.balena.io/etcher/) to create a bootable USB flash drive or DVD as required. Mac users need to perform an additional step to create a boot menu that allows them to install (and later select) Elementary OS—the "Mac Dual-Boot Considerations" boxout reveals what you need to do.

›› We also recommend turning off Fast or Quick Boot in Windows—this enables you to properly shut down your computer and reboot into either operating system



© ELEMENTARY

TOUR THE ELEMENTARY INTERFACE



1. LAUNCHER
Click here to access a complete list of installed applications. Once you've installed a few, use the category view to filter the list by type, or type into the search box to find the app you're looking for.

2. SYSTEM SETTINGS
In keeping with its slick, minimalist approach, Elementary's System Settings tool is sparsely populated. The "Mouse" section shown here does at least offer plenty of options.

3. DOCK
The Dock is the equivalent of the Windows taskbar, providing access to both open windows and favorite shortcuts. Right-click an item for more options.

4. CALENDAR
As with Windows (and macOS), the date at the top of the desktop provides a convenient shortcut to both a monthly calendar and a list of events. Double-click to open the main Calendar app.

5. FILES
Navigating your filesystem—as well as any connected servers and network drives—is a breeze, thanks to the Files app. Again, it lacks advanced customization options, but is familiar and easy to use.

6. MENU BAR
This area at the top-right provides a shortcut to key system tools, notifications, and the all-important power and login options.

without problems. To do this, go to "Settings → System → Power & sleep," and click "Additional power settings." Click "Choose what the power buttons do" followed by "Change settings that are currently available" to uncheck "Turn on fast start-up (recommended)." Click "Save changes."

» Once your partitions are in place, and your boot media has been created, you're ready to start installing your new OS. Connect the Elementary installation media, then reboot your PC or Mac—Windows users need to bring up the boot menu (typically by tapping a key such as F11), then choose the USB drive (UEFI if offered); Mac users need to select the "Boot EFI\boot\grubx64.efi" option from the boot menu. If the Elementary logo appears, press Enter.

» Once the main "Install" menu appears, simply click "Install Elementary." The process is practically identical to installing Ubuntu, upon which Elementary is based. Work your way through the initial setup screens: First, you need to select your keyboard language and layout, connect to your Wi-Fi network if prompted, then check "Install third-party software for..." before clicking "Continue."

3 CHOOSE WHERE TO INSTALL

The trickiest part of the whole process is choosing where to install Elementary. Make sure you select "Something else" under the "Installation type" screen, then locate where you plan to install Elementary—it'll be free space if you partitioned in Windows, or FAT32 if you followed our advice on the Mac. Mac users should highlight the FAT32 partition (be very sure it's the correct one), then click the "–" button beneath it to remove it and leave free space in its wake.

» Now select the free space—first create a swap file by clicking "+" and then set the swap file to 4096MB and its location as "End of this space." Click the "Use as" drop-down menu and choose "swap area." Click "OK." Now select the remaining free space and click "+" again. Leave everything as it is—including "Ext4 journaling file system" as the "Use as." Set the "Mount point" to "/" [**Image B**]. Click "OK."

» The only remaining consideration is where to set the GRUB boot loader—in most cases, the default

rEFInd
Boot EFI\boot\grubx64.efi from 2 MiB FAT volume
Use arrow keys to move cursor; Enter to boot;
Insert or F2 for more options; Esc to refresh

MAC DUAL-BOOT CONSIDERATIONS

Mac users need to install the rEFInd boot manager to install Elementary OS alongside macOS. First, disable System Integrity Protection—reboot your Mac, holding Cmd-R until the Apple logo appears. When the recovery environment starts, choose "Utilities → Terminal." Type "csrutil disable" and hit Enter, then restart.

Next, download rEFInd from www.rodsbooks.com/refind/getting.html—click "A binary zip file" and save it to your "Downloads" folder. Double-click the downloaded zip file to extract its contents, then open the extracted folder ("refind-bin-0.12.0" or similar). Next, open Terminal via "Applications → Utilities," and drag the "refind-install" script file from the Finder window into Terminal.

Press Enter and provide your account password to allow rEFInd to install. It should end with an "Installation has completed successfully" message, so restart your Mac, and the rEFInd boot menu should appear, which you navigate with the cursor keys. The boot menu always defaults to the last OS you booted into, so press the down arrow key to select the "Apple Recovery" option, then hit Enter. Once loaded, type "csrutil enable" in the Terminal to re-enable SIP (every time you want to reinstall rEFInd, you must disable SIP first). Reboot back into OS X proper.

"dev/sda" (first internal hard drive) should be correct. Click "Install Now." Read the warning, then click "Continue."

4 COMPLETE INSTALLATION

Two steps remain: First, pick your time zone (start with your city, then try state if it doesn't show up), and then set up your computer name, and create a user account. If you plan to share a data partition with macOS, it's crucial that this is identical (username and password) to your macOS account for file and folder permissions purposes. More on that later.

›› Once set, click "Continue," then sit back and let Elementary OS finish installing. After being prompted to restart now, unplug the install media, then restart. Windows users should see the familiar GRUB menu, offering a choice of which OS to boot into [**Image C**]—jump to step 5.

›› Mac users will find that rEFInd (and the ability to boot into macOS) has vanished. To bring it back, follow the tour in the next step, then open Epiphany to download the same rEFInd binary zip file as outlined in the boxout above. Open '"Applications → Files" and navigate to "Downloads," right-click the zip file, and choose "Extract Here." Open the newly created "refind-bin" folder, then right-click inside the "Files" window and choose "Open With → Terminal." Finally, type this command:

```
$ ./refind-install
```

›› Enter your account password when prompted and a series of messages should appear, confirming that rEFInd is the default boot manager once more. Restart and you can now switch between macOS and Elementary.

5 TAKE A TOUR

A short welcome tour accompanies your first boot, including links to online help and support. Take the time to run through it—you can enable location services, plus switch on Night Light to prevent eye strain when using Elementary late at night. There's also a Housekeeping section with options to automatically clean temp files and the trash after 30 days. You'll also be prompted to get more apps via AppCenter and open System Settings—skip both to complete the tour.

›› The annotation on the previous page reveals the key elements of the Elementary desktop—as point-and-click experiences go, it's very slick and reminiscent of macOS, but under the hood it's Ubuntu 18.04 LTS. If necessary, click the Wi-Fi icon to connect to your wireless network, then keep an eye on the AppCenter icon in the dock—you should see it's got updates to install, so first step is to open this and switch to the "Installed" tab where, after a short pause, you should see what's available. Click "Update all" and enter your password when prompted, then wait while Elementary brings itself up to date.

6 GET MORE APPS

One area where Elementary has traditionally exhibited more control over users is through its app support. Start your search, naturally, in the AppCenter—you can browse or use the search box to try to track down your chosen app. Apps are split into two categories: curated and non-curated. Curated apps are more vigorously tested, but non-curated apps should work in most cases, and you'll find popular apps such as LibreOffice, VLC Media Player, and the GIMP image editor here.

›› You'll notice some apps appear to come with a price tag attached—this is a suggested donation that you can change by clicking the down arrow next to the price to alter the amount (set it to "0" to skip this).

›› If you can't find an app, take a trip to https://flathub.org in your web browser of choice (Epiphany comes pre-installed, but both Firefox and Chromium are available through the AppCenter). Find your app here and you can simply click the "Install" button to open it using a brand new helper app called SideLoad. This provides

D
Bitwarden
A secure and free password manager for all of your devices
INSTALL
Install untrusted app?
This app is provided solely by its developer and has not been reviewed for security, privacy, or system integration.
Download size may be up to 726.9 MB
Updates to this app will not be reviewed
Other apps from this distributor may appear in AppCenter
I understand
Cancel
Install Anyway

some useful information and asks you to confirm you wish to continue [**Image D**] before clicking "Install Anyway." These Flatpak apps then appear in AppCenter, where you can update and remove them easily as you see fit.

» Techies looking for more sources of apps—individual repositories, or support for installing software packaged as .deb files—will find Elementary less accommodating. However, it's simply a case of installing the relevant packages: `sudo apt install software-properties-common` to trigger support for `add-apt-repository` and `sudo apt install gdebi` for .deb files.

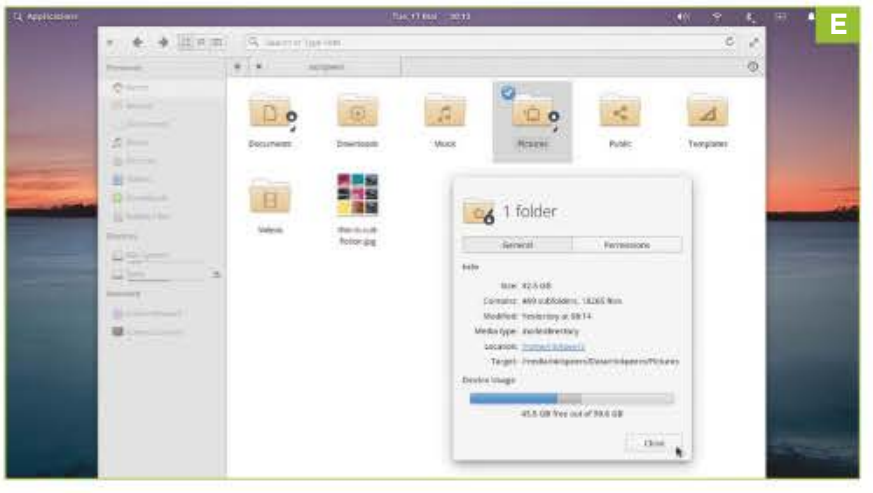
7 MASTER FILES

Navigating your filesystem is a crucial part of any OS, and Elementary is no different. To this end, it supplies the Files app—which you won't find on the dock by default. Instead, click the "Applications" shortcut in the top-left corner of the desktop. Here you can browse by application, switch to a categories view, or use the search tool to find what you're looking for.

» Files is basically identical to its Ubuntu counterpart, with one key consideration: Folders and files are opened with a single click rather than a double-click (see the tweaking box on the right if this is a problem). You should see your shared data partition appear in the list under "Devices." If it's an NTFS partition, you should find you can access your Windows user folders with no problems, but Mac users must jump through additional hoops.

» First, you need to change your Elementary user's ID to match your Mac's. In most cases, your Mac user account will be set at 501 or 502 (if you're not sure, open "System Preferences → Users & Groups," click the lock to make changes, then right-click your user name, and choose "Advanced Options" to verify it. Boot back into Elementary and then open "System Settings → User Accounts." Create a temp user with Administrator credentials, then log off your own user profile, and log into the temporary one. Now open a Terminal window and issue the following commands:

```
$ sudo usermod --uid 501 yourusername
```



TWEAK YOUR SYSTEM

Most system tweaks can be performed from System Settings, but they might be hidden away. For example, need to change the desktop resolution? Select "Displays," then click the settings cog in the top-right corner, and you'll see options based on your display's capabilities. Want to secure your network connection through a VPN? Head to "Network → VPN" to import OpenVPN profiles from your provider.

If you can't find the tweak you're looking for, a range of third-party tools can do the job. Advanced techies should examine dconf Editor (`sudo apt install dconf-editor`), but those with more limited ambitions—such as disabling the annoying "single-click opens files and folders" behavior in Files—should install elementary-tweaks via the Terminal:

```
$ sudo add-apt-repository ppa:philip.scott/elementary-tweaks
$ sudo apt install elementary-tweaks
```

Once done, open System Settings to find the "Tweaks" shortcut under "Personal." Select this followed by "Files" and you'll see the switch to toggle single-click off and on. You'll also find options under "General" to customize the desktop, plus an option for the Applications Launcher to open with the Category view shown by default—as your app collection grows, this becomes a more practical view.

```
$ sudo chown -R 501:yourusername /home/yourusername
```

» Substitute your Elementary username for "yourusername" and "501" with the same ID as your Mac user. Next, you need to ensure your user profile remains visible on the logon screen:

```
$ sudo nano /etc/login.defs
```

» Scroll down and locate the "UID_MIN" entry, then change it to your new user ID (501 or 502). Save the file (Ctrl-O) and close nano (Ctrl-X). Restart Elementary and boot into your own user profile—you should now have read and write access to your Mac's user folder. You can delete your temp user via User Accounts or a Terminal command (`sudo userdel -r tempuser`).

8 LINK USER FOLDERS

The final stage of integrating your data folders is to link the folders in your Elementary user's home directory to your data partition. You don't need to do this with all folders—it makes sense to keep "Downloads" separate, for example—but you can easily do it with folders such as "Documents," "Pictures," and "Music."

» The simplest way to do this is through Files. Open it to your "Home" folder, then delete the existing (and presumably empty) "Documents" folder. Now click "+" next to the folder name to open another tab, then navigate to the folder containing your shared "Documents" folder. Right-click this and choose "Copy as Link." Switch back to the original folder and choose "Paste Link." You should see the tell-tale arrow on the folder icon indicating it's a link—click it and you'll see it now points to the shared folder. Repeat for any other folders you wish to link in this way [**Image E**].

» One final tweak—you'll notice that deleting the original folder also removes its shortcut from the Personal sidebar. Simply drag the folder on to the sidebar to add back its shortcut.

Step Up Your Password Security

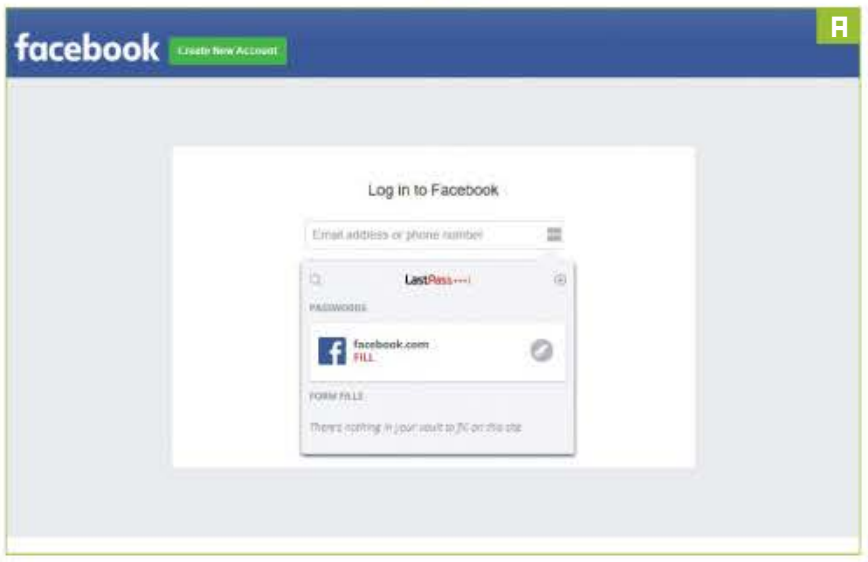
YOU'LL NEED THIS

LASTPASS ACCOUNT
Sign up for free at http://lastpass.com.

WE ALL KNOW WE NEED to use stronger passwords—"password123" is not a good choice and never has been—but doing so can seem like a daunting task. How do you know what constitutes strong passwords? Where should you store them all? And won't it be a hassle to go through all your accounts and give them strong security?

Fear not, because you can take the pain out of the situation by using LastPass. It's a password manager that handles everything for you, from suggesting strong passwords to filling them out for you and storing your other important info, including addresses and credit card details. It can even automatically scan your accounts, find weak passwords, and, where possible, change them for you. Best of all, it's 100 percent free to use for individual users.

All you need to remember is your master password, which grants access to your LastPass Vault. Make this strong—it needs to be at least 12 characters long, including at least one number, one uppercase letter, and one lowercase letter. Once done, you'll never have to remember another password again. –**ALEX BLAKE**



1 SET UP LASTPASS

On Windows, LastPass works as a web browser extension. Head to http://lastpass.com, click "Get LastPass Free," and create an account, then click "Install LastPass" to add it to your browser of choice. Once it's set up, click the LastPass icon, then log in to access your Vault.

›› Now that LastPass is set up, every time you log in to a website, LastPass offers to remember the password for you. When the "Add to LastPass?" box appears, just click "Add," and the password is stored in your Vault.

›› When you visit a website that has a stored password, you'll see a small LastPass icon in the username and password entry fields. Click this and a small box appears, showing the accounts that LastPass has stored for this website [**Image A**]. Simply hover over the account you want to use, click "Fill," and LastPass then enters the username and password for you.

›› That makes logging in a real cinch. Instead of having to remember all your passwords, and which one is for which website, LastPass does it for you. The only thing you need to remember is your master password.

2 MANAGE SAVED PASSWORDS

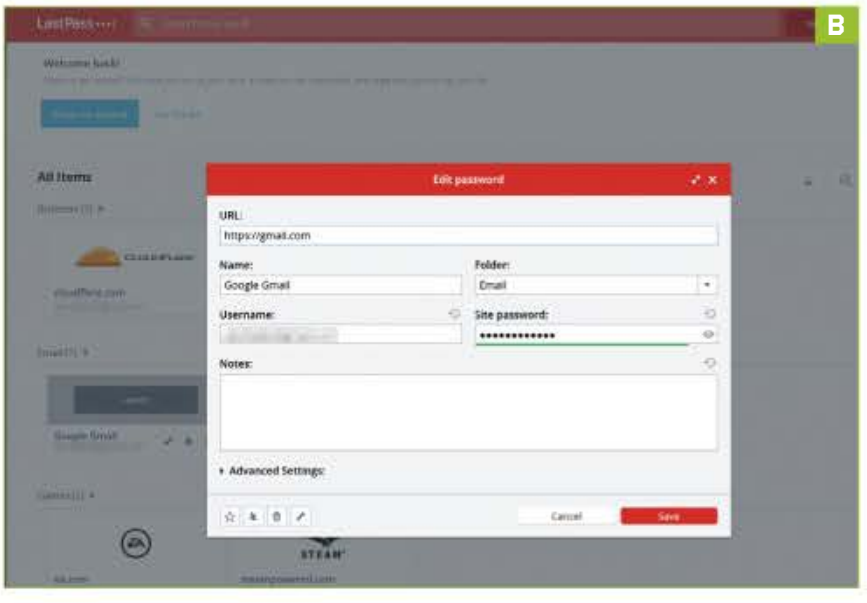
You can quickly view all of your saved accounts and passwords by clicking the LastPass icon in your browser, then clicking "Open My Vault." This takes you to your LastPass Vault homepage. The first thing you'll notice here is a list of all your saved accounts, grouped into folders by type. Hover over a saved account and a few options appear: "Launch," "Edit," "Share," and "Delete."

›› Click "Launch" to be taken to the login page for that particular website. If you want to send the login details to someone else, simply click the "Share" button; you can choose whether to allow the recipient to view the password as well.

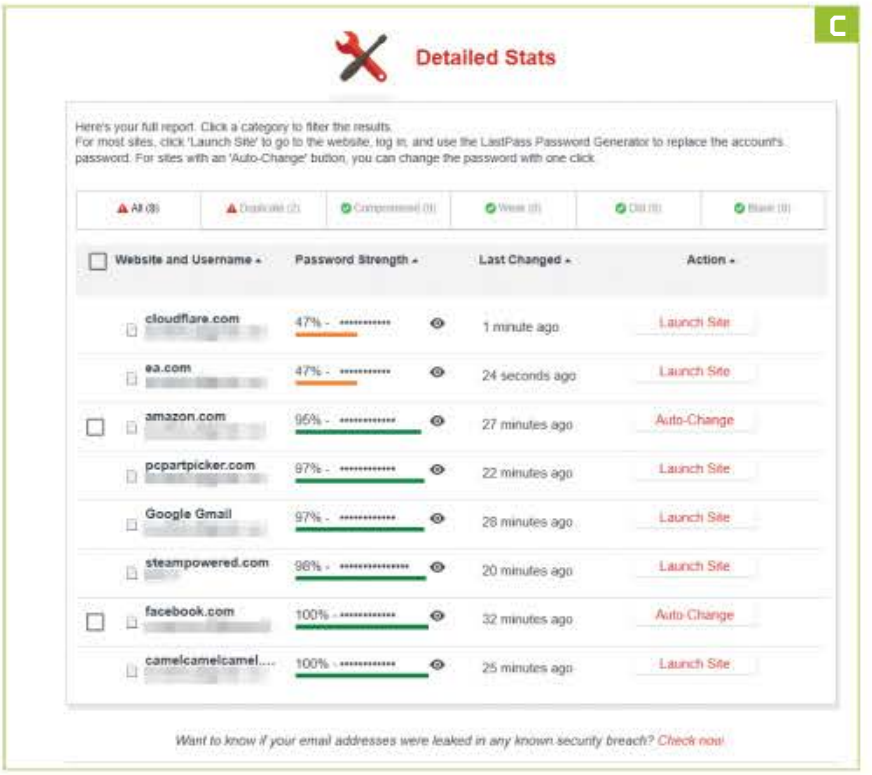
›› Click the "Edit" button to view all the stored details for each account [**Image B**]. Here, you can amend the account name, change your login username and password, and add any notes you want to. You can also change the website address for the account, as well as the folder it's stored in. Under "Advanced Settings," there are options to require you to enter your master password before LastPass autofills the password for this account, to allow you to automatically log in, and to disable autofill for this website.

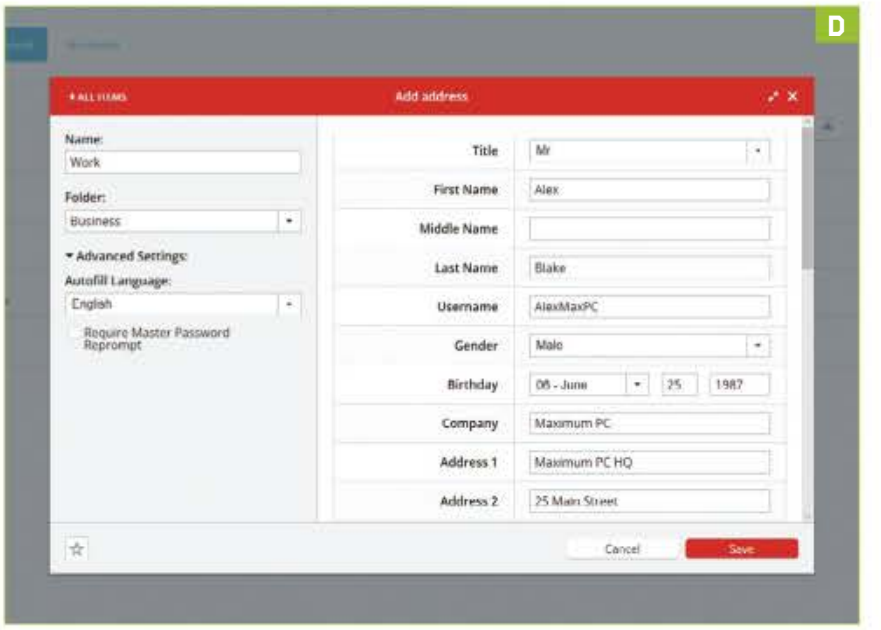
3 CHECK PASSWORDS FOR WEAKNESSES

One of the best features of LastPass is its Security Challenge. This analyzes all your saved passwords and indicates which ones are weak or



© LASTPASS





duplicated. It can even automatically change your passwords on certain websites. To get started, click "Security Challenge" in the left-hand sidebar, then click "Show My Score." You have to enter your master password, then LastPass gets to work examining your passwords, which takes a few seconds. When it's finished, you get a breakdown of your overall security score, how it compares to other LastPass users, and how strong your master password is.

›› Underneath that, you'll see tips on how to improve your score. The Security Challenge highlights passwords that have been included in data breaches, ones that are weak or that you have reused, and ones that haven't been changed in a long time. Click the "+" button to expand each section and see which passwords you should change. If you have multiple accounts in one section, you can check the box next to each one, then click "Update Now" to have LastPass automatically change them.

›› Scroll down to the "Detailed Stats" section [**Image C**]. This ranks all of your passwords from worst to best, giving each a percentage score. If you have an account with certain large websites, such as Amazon and Facebook, you can click "Auto-Change" and LastPass automatically opens the site and changes your password to a much stronger alternative. Otherwise, click "Launch Site" to go to the website in question, where you can log in and change your password yourself.

›› At the bottom of the Security Challenge page is a button to check whether any of your email addresses have been included in data breaches. If they have, it's a good idea to change the password for any account that uses the same email address.

4 ADD ADDRESSES AND MORE

You don't only have to use LastPass for your usernames and passwords—it can also store addresses, credit card details, and bank account information, then automatically fill out these details when required.

›› Unlike passwords, LastPass doesn't ask to save your address details once you've filled them out on a website, so you have to save them manually. In your LastPass Vault, click "Addresses" in the left-hand sidebar, then click the large "+" icon. Enter as many address details as you want [**Image D**], then give the address a name. You can add it to a folder if you like, and add attachments (such as a map screenshot if you want to share it with someone). You can set some advanced options, such as the autofill language and whether you should be prompted for your master password, and you can also click the star icon to add the address to your favorites. When you're done, click "Save."

›› The process is the same for payment cards and bank accounts. Click the relevant option in the left-hand sidebar, then enter as many details as you need. Click "Save" to store the information in your Vault. Now, whenever you go to pay for something online or set a delivery address, LastPass offers to fill out the information for you, helping to save you time.

›› LastPass also allows you to save secure notes. This can be any information that you want to keep safe that doesn't fit into the other categories—details about a surprise gift for someone, for example, or your passport number. Like everything you save in LastPass, this info is encrypted, keeping it hidden from prying eyes.

PREMIUM EXTRAS

LastPass lets you use all its essential features for free, but you may find yourself wanting some of the extras in the Premium subscription service. These include priority tech support, extra storage space for documents and attachments, and advanced authentication options, allowing you to use YubiKey devices or your fingerprint, among other things. One of the most useful paid-for features is being able to use LastPass in your apps. In the free version, you're limited to websites, but this feature lets you autofill passwords, addresses, and more from within programs—useful for logging in to Steam, for example.

We also like the emergency access premium feature. With this, you can designate a trusted person as your emergency contact, giving them access to your information if you're unavailable. You can choose how long they need to wait until gaining access, and can revoke access if you think it's been requested unnecessarily. It's a feature that's particularly useful with shared bills or mortgage payments, and it might just get you out of a tight spot in unforeseen circumstances.

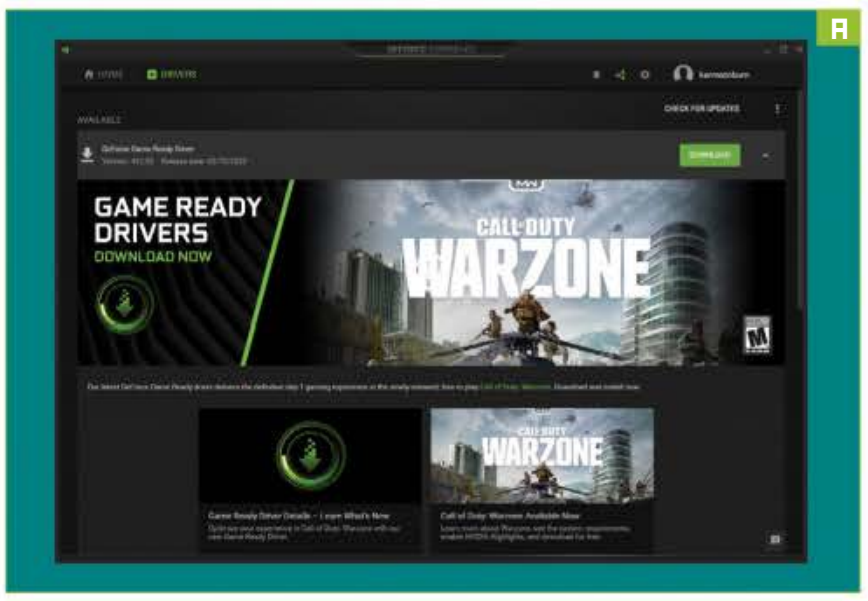
Enable G-Sync on a FreeSync Monitor

YOU'LL NEED THIS

A FREESYNC COMPATIBLE MONITOR
Stating the obvious, but this doesn't work with just any panel; you need FreeSync on your screen's specs.

GRAPHICS CARD
An Nvidia RTX 20-series or GTX 10-series GPU.

THE PROBLEM IS CLEAR AND SIMPLE: Sometimes games produce screen tearing and stuttering. They don't mean to, it's just a function of the way your graphics card and monitor interact—GPU spews out frames as quickly as it can, monitor uses those frames at a set refresh rate, gamer looks on at torn images in frustration. This being the wonderfully infuriating world of personal computers, it's the solution that proves far more complex. V-Sync is the simplest band-aid over frame pacing issues, telling your GPU at the software level to only provide as many frames per second as the current refresh rate—usually 60. It's effective in its own way, but often introduces noticeable input lag and tanks the frame rate down to 30 if your graphics card can't handle a consistent 60. Nvidia's G-Sync and AMD's FreeSync both offer more complex hardware-based delivery pipelines for new frame data, but previously they didn't interface—G-Sync needed a compatible monitor and an Nvidia card, while FreeSync required AMD silicon in your PCIe slot. Now the walls have come down, though, and Nvidia has enabled G-Sync on FreeSync panels. We'll show you how to get it up and running. **–PHIL IWANIUK**



1 UPDATE YOUR NVIDIA DRIVERS

That's right, we're starting with everyone's favorite chore: a driver update. GeForce Experience prompts you on the desktop whenever a new Game Ready Driver is available, but just in case you've missed one—or indeed, quite a few—open GeForce Experience, select the "Drivers" tab, and hit the green "Download" button if you see one [**Image A**]. If it's not there, your drivers are fully up to date. You need at least version 417.71 to use G-Sync with a FreeSync panel, so chances are you already have compatible drivers by now—support was enabled way back on January 15, 2019. It was a simpler time. Coronawhat?

›› Contained within these updated drivers is information that adds the option to enable G-Sync in Nvidia Control Panel, and tells your GPU not to produce more frames than a variable refresh rate monitor's current Hz when G-Sync is turned on.

2 HOOK UP A DISPLAYPORT CONNECTION

HDMI won't cut it for this exercise, and although we're still deeply in love with chunky old DVI, it's not going to cut the mustard either. You need a DisplayPort cable between your graphics card and monitor for this one in order to enable G-Sync. Adaptive sync has been woven into DisplayPort's feature set since version 1.2a, so you don't need to worry overly about which DisplayPort cable you use. Your screen and GPU just need a nice high-bandwidth interface to communicate through, and because HDMI 1.4 tops out at 1080p and 60Hz, it can't keep up. HDMI versions 2.0, 2.0a, and 2.1 can go beyond those numbers, but they're rare to find on variable refresh rate monitors' back panels. Mini DisplayPort is fine, if you were wondering.

3 CHECK YOUR MONITOR'S COMPATIBILITY

So, your graphics card meets the requirements, and it's using the drivers needed too. You've got a DisplayPort cable connecting it to your monitor, and you're primed and ready for silky-smooth frame delivery. What next? Well, next is a bit of expectation management. Nvidia itself has tested over 400 different monitor models with variable refresh rate on their spec lists, and of those 400, it's certified, er, 12. Aka "not very many." Here's the list of fully certified models—if yours is name-dropped, you can guarantee total compatibility: Acer XFA240, Acer XG270HU, Acer XV273K, Acer XZ321Q, AOC Agon AG241QG4, AOC G2590FX, Asus MG278Q, Asus VG258Q, Asus VG278Q, Asus XG248, Asus XG258, and BenQ XL2740.

›› What's Nvidia's criteria? Partly it comes down to the ratio of refresh rates a given panel offers. The screens that made the grade offered 2:4:1 refresh rate ratios or higher (that's at least 48–144Hz, to put it in more relatable terms). When G-Sync was enabled on these

Set up G-SYNC
B
1. Apply the following changes.
Enable G-SYNC, G-SYNC Compatible
Enable for full screen mode
Enable for windowed and full screen mode
2. Select the display you would like to change.
3. Display Specific settings.
Enable settings for the selected display model
Selected Display is not validated as G-SYNC Compatible.

© NVIDIA

panels, they exhibited no off-putting behavior, such as blanking, pulsing, flickers, ghosting, or any other artifacts.

» If your panel isn't, by a remarkable stroke of luck, one of those 12, that doesn't mean you can't use G-Sync with it. Just prepare for the odd glitch or compatibility issue. Ultimately, it's up to you to determine whether you feel the benefits, and weigh them up against any issues that might creep in.

4 ENABLE VARIABLE REFRESH RATE

This step's about delving into that darkest, most un-user-friendly of domains in all of PC gaming: your monitor's settings menu. And, unfortunately, we're not talking about Windows display properties but the real deal: that baffling array of terse criteria you bring up on your screen by hammering a random selection of flimsy plastic buttons, placed at the least easily accessible height and angle possible. Seriously, we've got UEFI BIOSes with full mouse support, but our monitors can't handle more than an unresponsive flip-book of settings?

» Soapbox dismantled. For this step, you simply need to ensure that your own monitor has variable refresh rate enabled in its settings menu. Many don't come out of the box with this enabled either, so it's definitely worth checking. Unfortunately, we can't guide you through the specific labyrinth of your panel's options, but if you're not out of there in 10 minutes, we'll call the police to come and rescue you.

5 ENABLE G-SYNC IN NVIDIA CONTROL PANEL

Now comes the relatively easy part. With all your hardware complying to requirements, all that's left is to open up Nvidia Control Panel and turn G-Sync on. You can access Control Panel by right-clicking the Nvidia icon in your system tray—you might need to click the arrow first to "show hidden icons"—or simply by looking for it in Windows Search Bar next to your Start icon [**Image B**]. Once you're in, head to the "Display" header then "Set up G-Sync." Now check the "Enable G-Sync G-Sync Compatible" option, and enter the options you want to use. Select your monitor in the drag-down menu, then check "Enable settings for the selected display model" and "Apply settings." Congratulations, you've turned FreeSync into G-Sync.

6 TEST YOUR RESULTS

Is your work over? Forget it. Next you need to ascertain just how compatible your monitor is with its new-found G-Sync functionality. The best way to do it is to load a particularly demanding game, something you'd expect to see reasonable frame rate variance in, such as *Metro Exodus* or *Battlefield V* [**Image C**]. Keep an eye out for freezes, flickering, or any other odd behavior that wasn't present in your monitor before. If you do see something odd, there's not much recourse at this point. Again, it's a matter of weighing the pros against the cons, and deciding whether to keep that G-Sync box checked. There's always the possibility that future driver updates from Nvidia might improve things, too, so don't write it off completely if your panel won't play ball at this point.

7 DO YOU PLAY BETTER WITH OR WITHOUT?

Finally, there's one more question to face: Maybe you can play with G-Sync now, but should you? If you're a competitive FPS player, you might actually prefer to leave it disabled. Running games at high frame rates that go above your monitor's highest refresh rate could introduce some input lag, and in some titles, that's a game-breaker [**Image D**]. If the title in question allows you to set a frame limit, you can minimize that lag by setting the cap below your refresh rate. Some players might simply prefer to game at 300fps and go without G-Sync altogether, though. With margins this small—and they are small—it comes down to feel. And if something feels smoother with G-Sync enabled, then lean into it, and happy headshotting. But if not, don't feel like you're missing out if you prefer the responsiveness of an unsynched 300fps.

A G THING

Why would you even want G-Sync over FreeSync, or even V-Sync for that matter? Let's delve into the specifics of how Nvidia's frame-pacing solution works. Because monitors and graphics cards operate at completely different cadences in a non-G-Sync environment, screen tearing and stuttering kick in when the graphics card's render time is slower than the monitor's refresh rate. It hands over incomplete frames for the screen to update itself with, or simply doesn't deliver the goods in time and skips frames. By adding an additional bit of circuitry into the monitor, G-Sync makes the refresh rate march at the beat of your GPU's drum, rather than the other way around. It means you're always seeing complete frames on screen, because your monitor only ever asks your GPU for a new frame once it's done rendering it.

This doesn't magically eradicate any variance from the frame pacing, but it lessens the severity of the effect. Watching a game go from 60fps into the low 20s is a jarring experience without any kind of frame pacing solution, but assuming your GPU can at least match the screen's lowest adaptive refresh rate (usually 48Hz and thus 48fps), you won't see stuttering with G-Sync enabled.

Machine of the Month: Sharp X68000 (1987)

YOU'LL NEED THIS

32-BIT X86 CPU WITH MMX, WINDOWS 2000, OR LATER
Or you can use a solid version of Wine under Linux.

XM6 PRO-68K
Download it from https://bit.ly/2TjiAF4.

THE ATARI AND AMIGA may have had their adherents, but when it comes to gaming, the Sharp X68000 is in a league of its own. Dubbed "The God Computer" by the Japanese, the X68000 (or X68k for short) is perhaps the ultimate in 16-bit gaming. While console makers such as Sega and Nintendo often boasted "arcade-like" graphics, the X68k was the first home machine to provide genuine arcade graphics. The X68000 might not be famous in the West (it was only sold in Japan), but those in the know can expect near-perfect arcade ports.

However, X68k ownership is an eye-wateringly expensive proposition, with any half-decent disks costing several hundred dollars, let alone the cost of the hardware itself. For most of us, emulation is the only option. Nevertheless, it can be tricky to know where to start, and that's not even taking into account the language barrier of the Japanese operating system. So, let us do the hard work for you, as we explore The God Computer, the Sharp X68000. –JOHN KNIGHT

1 HISTORY LESSON

Launched in March 1987, the X68k was an intimidating machine. Although it shares the same Motorola CPU as its American counterparts, spec for spec, the X68k wipes the floor with its Western competitors, and was intended to dethrone NEC's PC-98 from its top position in Japan. Launching with a full megabyte of RAM (minimum) its CPU was 2MHz faster than the American's, and its sound chip was top of the line. It even had 1MB of VRAM. However, the price was as intimidating as the performance—around 7,000 dollars in today's money.

›› Those who could afford the machine enjoyed essentially perfect versions of arcade megaclassics such as *Strider, Final Fight,* and the world-dominating *Street Fighter II.* This was hardly surprising, though, because the underlying hardware was already similar to that of arcade machines—Capcom even used the Sharp as a development machine for its arcade cabinets. The results were often genuinely perfect arcade ports, or at the very least, near-perfect ports with very little compromise.

›› The X68000's primary OS was Human68k—an MS-DOS-like operating system developed by Hudson Soft. On top of this DOS base were multiple desktop environments—like early versions of Windows on the PC—including Visual Shell, SX-Window, and Ko-Window. However, these interfaces were a kind of mashup between the Mac, Amiga, and NeXTSTEP operating systems.

›› Despite being known as a gaming platform, it was also marketed as a multimedia platform, with various packages for video, image, and sound editing, none of which were particularly famous. Although it was more than capable as a multimedia desktop (like the Amiga and ST), it was a gaming machine first and foremost. It even had a port for stereoscopic 3D goggles.

›› Gaming-wise, there's a ton of side-scrolling shooters—they actually make up a bulk of the Sharp's titles. Despite being famed for Japanese arcade titles, X68000 software is a mixture of East and West, with arcade classics and home micro titles from both the 8-bit and 16-bit eras.

›› Many will be surprised to find titles such as *Future Wars, Lemmings,* and *Xenon 2 Megablast.* As for Japanese cult gaming, try *R-Type, Cotton, Neural Gear,* and the jaw-dropping *Geograph Seal.* Especially famous among gamer geeks is a reworked version of *Castlevania* with a new engine, and upgraded visuals and audio, available only in Japan and only for the X68000.

›› The X68000 would be improved year by year, with the final machine shipping a standard 4MB of RAM, a 25MHz 32-bit 68030 CPU, and an optional 80MB SCSI hard disk. All kinds of upgrades were released, such as video accelerator cards, SCSI hard drives, and newer CPUs, but it was finally discontinued after 1993, when IBM-compatibles eventually dominated local Japanese systems.

2 EMULATING THE X68000

Although options such as MAME and RetroArch exist, we would prefer to use something bespoke. XM6 Pro-68K (https://bit.ly/2TjiAF4) runs nicely on just about any version of Windows and under Wine on Linux, and is well documented by its fastidious author.

3 INSTALLATION

The installation is slightly complicated due to some distribution issues, but things may be improved by the time this hits print. The website provides three zip files: the chief file is XM6 Pro-68k.zip, and is all that is technically necessary to run X68000 software. You need to extract the zip file and open the application (XM6.exe) manually from the main folder—if you plan on using XM6 Pro-68k a lot, you might want to make a desktop shortcut.

›› The second two files, XM6 Pro-68k DLL Package and XM6 Pro-68k Web Package, aren't system-critical but do enable updates and correct issues, such as

›› Choosing one game would be difficult, but 1989's *Final Fight* is an all-time classic in both Japan and the West.

© CAPCOM

›› Collector Gary Pinkett shows us his popular black tower variant, running the SX-Window desktop.

missing fonts. To install the files, simply extract the packages into the main folder of XM6 Pro-68k.

4 USAGE

On first boot, you're presented with a screen known to any X68k user: some Japanese writing and a picture of a floppy disk. The machine has no OS at this point, but most games you download (remember, you must have bought your own copy back in the day) include Human68k in their disk images.

›› Most disk images boot themselves, so try your luck by opening the main menu and choosing "Floppy Drive #0 → Open" and selecting your disk image. Floppy Drive #0 is your main drive, so run your disk images from this drive, and if your game is spread across multiple disks, open the first disk on Drive 0 and the second disk on Drive 1.

›› When games don't load automatically, you'll probably be stuck at Human68k's command prompt. Despite being Japanese, the OS uses English commands, and is similar to MS-DOS, except it uses a .X file extension instead of .EXE. If you've never used DOS before, don't panic.

›› To browse your disk's contents, enter the command `DIR`. The current directory will display, with filenames on the left and extensions on the right. You want to look for batch files with the extension .BAT, or executables with the extension .X—you should try running any batch files before running an executable. If your batch file has something like START on the left and BAT on the right, type `START` and press Enter. If your executable has something like GAME on the left and X on the right, type `GAME` and press Enter.

›› If you find yourself stuck at a game's intro screen, you may need to change the input method. This is found in the main menu under "Tools → Controller Mode." Some games and graphical environments use the mouse, which can be activated by selecting "Mouse Mode" or middle-clicking inside the main window.

›› Although most games can use the keyboard, they almost all use a different set of keys. To avoid a lot of trial and error, we recommend plugging in a USB joystick, which can be configured under "Tools → Options."

FIND SOFTWARE

While much of the X68000 collection is Japanese only, thankfully a lot of action titles are in English—or have at least enough English to make your way. Unfortunately, the Sharp's software library isn't as extensive as other platforms we've covered, nor does it have the same kind of modern hobbyist scene. Don't be dismayed, though—there is plenty of software on ROM sites (and more than enough to keep you going), we just can't legally point you toward most of it.

Retrostic.com claims to have a collection of software that is only out of production, and hasn't been hit with a big legal hammer yet, so it might be worth a try. Archive.org has an enormous 16.6GB software collection, as well as the "Gekkan Dennō Club Perfect Collection 1997." There are also user manuals, system ROMs, and community videos, so they can deal with any legal headaches!

For any interested users, the author of XM6 Pro-68k runs a software preservation archive, with a link on the XM6 Pro-68K website. If you have any disks to contribute, please get in contact.

SPECIFICATIONS

Sharp X68000 (1987)

CPU:	Motorola 68000 @ 10MHz
RAM:	1MB (up to 12MB), 1MB VRAM
Launch price:	¥369,000
Graphics:	65,536 colors @ 512x512, 64 colors @ 1024x1024
Sound:	Yamaha YM2151, eight-channel, FM synthesis, dedicated ADPCM
Storage:	5.25-inch floppy, later hard disk upgrades
OS:	Human68k
Released:	March 1987
Production:	1987–1993
Worldwide sales:	N/A

›› YouTuber RetroManCave helping us out with his period-incorrect LCD pounding the legendary *After Burner.*

© GARY PINKETT

BUILD IT

ZAK STOREY, EDITOR

The $3,333 Pink Pariah

There's nothing quite like overkill for a living-room gaming PC

LENGTH OF TIME: **8-16 HOURS**

LEVEL OF DIFFICULTY: **COMPLEX**

THE CONCEPT

LET'S BE REAL HERE: This is overkill. Massively. We'd pitch this as a "console killer," but if we're being honest, with a price tag this large, you could probably buy eight PS4 Pros and still have enough cash left for six crates of beer and 20 packs of chips. In fact, this build is nothing short of gluttony. So, what was the aim of it? What did we set out to achieve with this rig? It was all about building something that could act not only as a big showpiece or ornament for the living room, but also as a system that could comfortably and quietly game at 4K on the big screen. And, of course, all from the comfort of your couch.

Our case of choice for this build is the Phanteks Evolv Shift X chassis. It's a long, monolithic ITX case, with an expressive internal structure and layout. It supports a hefty amount of hardware internally, including liquid-cooling radiators—but there are some limitations, thanks to clearance. In fact, most builds using the Shift X typically incorporate a single 240mm radiator and then call it a day. We knew, though, that this just wasn't going to be enough for the hardware we had in mind, so we opted to slot in an additional 120mm radiator at the bottom. That gives us a total of 360mm of cooling potential to play with. Not a lot, by any means, and it certainly meant we'd be running this thing at stock, but it's still plenty enough to cater for a 4K gaming GPU and a good CPU, too.

THERMAL WOES

THE BIG ISSUE with this build was balancing the hardware choices with the thermal capacity. Because we were going to be running a complete loop, and cooling the GPU as well, it was imperative that we got this right. We knew a single 240mm radiator would be more than enough for any processor we could pop in here, but adding a GPU complicates matters. There certainly wouldn't be any headroom for overclocking, that's for sure.

So, let's look at the main heat-generating components. First up is the Ryzen 5 2600X. Now, this is a fairly solid all-around processor—it's got a TDP of around 95W, and it comes with a beefy six-core, 12-thread setup, and a healthy clock speed that we can drop with the voltage if need be. For just gaming, it should be more than enough at 4K and beyond. On top of that, it also comes with streaming protection, so if Netflix and co ever get their butts in gear, we might actually be able to manage 4K streaming over this thing as well.

As for the GPU, we went with a fairly high-spec RTX 2080. We could have gone with a Ti model, which would have realistically been better for those 4K frame rates, but the Ti also comes with a 250W TDP—the RTX 2080, on the other hand, has a TDP of just 215W. That's a fairly substantial drop in overall power draw, making it ideal for our slim 360mm-rad setup. Outside of that, and to minimize the number of cables we'd need, we picked up a 1TB WD Black SN750 PCIe SSD. That was actually a mistake on our part. We assumed it would be like the latest Corsair Force PCIe 4.0 drives, and it would be easy to remove it from its heatsink. Oh boy, were we wrong—you need specialist torque screwdrivers, which are smaller than any we could find at the local hardware stores, but more on that later....

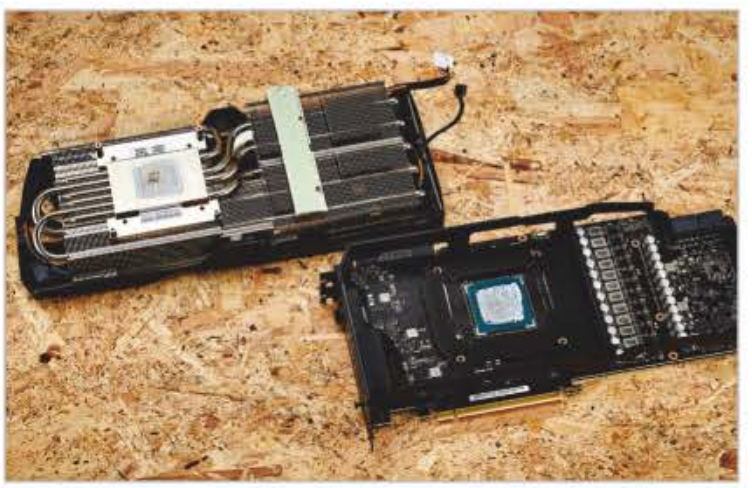
INGREDIENTS

PART		STREET PRICE
Case	Phanteks Evolv Shift X	$160
Motherboard	Asus ROG Strix X470-I Gaming	$210
CPU	AMD Ryzen 5 2600X	$146
GPU	Asus ROG Strix GeForce RTX 2080 OC Edition	$867
Memory	16GB (2x 8GB) Corsair Dominator Platinum RGB @ 3,200MT/s	$120
PSU	750W Corsair SF750 Modular 80+ Platinum	$400
Storage	1TB WD Black SN750 PCIe NVMe M.2 SSD	$195
Cooling	Assorted Phanteks, Alphacool, Mayhems	$1,072
120mm Fans	3x Phanteks PH-F120MP PWM (black)	$45
140mm Fans	1x Phanteks PH-F140MP PWM (black)	$18
Operating System	Windows 10 Home 64-bit	$100
Total		$3,333

1

GPU STRIP-DOWN

IT'S ALWAYS worrying when you have to strip down a graphics card to attach a waterblock. There's so much that can go wrong, it just doesn't bear thinking about. Just take your time, be careful, and make sure you don't overdo it with the screws. Asus's GPUs are fairly simple to take apart: Remove the backplate screws, those surrounding the GPU, and the card slowly pulls apart. Just remember to unclip the fan cables and RGB cables. For this build, we took advantage of a Phanteks waterblock for the first time. It doesn't come with a backplate for the Asus graphics card, so instead we reinstalled the GPU backplate after we'd finished. That means we still have the Asus ROG RGB logo illuminating the back of the card, entirely controllable in software.



2

CASE DISASSEMBLY

WITH THE GRAPHICS CARD blocked, it's time to strip down the case. The Phanteks Shift X is a pretty easy chassis to disassemble. The two tempered glass panels have thumbscrews at the top, near the rear I/O (which is also where the power button is). You simply pop up the top rear I/O panel—it's on a spring mechanism—loosen the thumbscrews, and slide the solid glass windows up and out. Stick them in the case box for safe keeping. The front and rear brushed aluminum panels follow a similar procedure. There are two thumbscrews either side, situated at a horizontal angle instead of vertical, then they just slide off. Inside you'll find an accessory box with drive trays, screws, and a nifty little box. We've also removed the power supply cover here as well.

3 MOTHERBOARD PREP

NEXT, IT'S TIME TO MOVE on to the motherboard. This presented a number of problems. First up was the block itself. Phanteks is fairly new at the waterblock game, and rather frustratingly, the block has two cables that you need to attach to control the RGB lighting at the top and bottom, and then find a way to route around the board. And then there was the hard drive. As we mentioned earlier, we didn't have the necessary tools to remove the heatsink, so that left us with just one option: Simply don't reinstall the stock motherboard M.2 heatsink. Ultimately, that does mean you lose out on a little RGB, but let's be honest—does that really matter all that much? We don't think so.

4 RADIATOR FITTING

INSTALLING THE 120MM RADIATOR was a nightmare—the shot you see below isn't even the correct orientation yet, as the ports are facing the power supply. We ended up moving it 90 degrees clockwise, so the ports face the window instead. This enabled us to mount our pump in a better position, to allow for easier tubing runs. You may have also spotted that it's not a Corsair power supply. We intended to use a Silverstone Strider, but even as an SFX power supply, it was too tight against the power supply cover. In the end, we went for the Corsair SFX PSU as it's a bit shorter than this one. We've also removed the kettle lead pass-through cable, as it's almost impossible to plug it in while attached to the case. You first to plug the pass-through into the PSU, then reinstall it to the case.

7 FITTING INFURIATION

THIS IS THE POINT we found out it wouldn't all fit. It's always smart to keep a few fittings out to see if you're going to run into any conflicts, and this is a prime example. Pump in, radiator in the correct position, reservoir sorta right, angled fitting in. Will the glass panel fit on? No. Back to the drawing board. Infuriating doesn't quite cover it. Especially as a lot had to be removed to move it back. This was also the first time we began to get an idea as to what tubing runs would be going where. Unlike most cases, where you can easily plan your tubing runs, the Shift X has a split compartment, with each segment consisting of half the case. With the motherboard on one side and the graphics card on the other, deciding how to position your tubing runs can be difficult.

8 CABLE AWARENESS

FINALLY, WE COULD TURN OUR ATTENTION to the motherboard itself, and it was clear fairly quickly that there were going to be some major issues here with regard to cabling. In fact, between that top-left corner and the fan, we'd somehow have to run an eight-pin power cable, plus all the fan cables, and the RGB cables. And then, of course, there were the tubing runs to fit in, too. The most obvious route—and something we'd eventually commit to—was to go straight through the top plate, around the rear I/O, and then down to the graphics card, although that would require some significant cutting and a pass-through to get working.

5 RESERVOIR RUMBLE

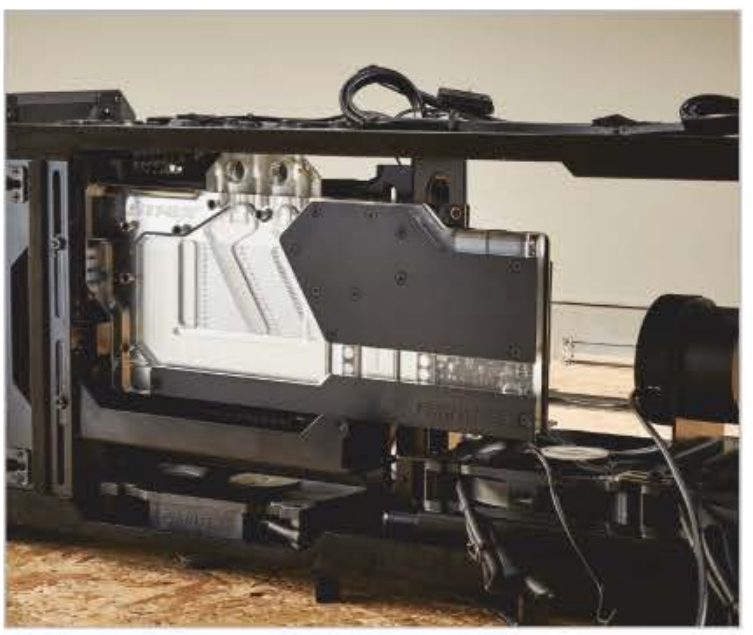
AT THIS POINT, WE STILL hadn't figured out that the Silverstone power supply was no good, but it was all about fitting that front radiator and getting the reservoir into position. We're actually using a separate bracket from Alphacool for this—as it's got channels down, you can orient them in different ways to give you better clearance and move the reservoir up and down as needed. It's not the cleanest look in the world, but it works well when you're trying to suss out those tubing runs on the first pass. We've also installed the LED RGB Alphacool ring. It's quite old-school in a lot of ways, as it isn't compatible with motherboards, and instead plugs in via Molex, then has a physical wired remote to control color and illumination patterns.

6 PUMP POSITIONING

BY NOW, WE'VE REALIZED that having the radiator ports facing the PSU is a no-go, so we've reoriented it to the correct position, with the ports close to the glass window. And we've also taken the opportunity to mount the pump to the top of the radiator, raised off it—this time, with the included Phanteks pump mount that came with the case. You can mount the bracket directly to 120mm fan mounts on a case, making it perfect for our bottom radiator. We're still tinkering with the positioning here, and it turns out that the pump itself is too close to the window to allow for the 90-degree fittings that we're inevitably going to need to install. Fortunately, the pump mount bracket has multiple slots to which you can attach the pump.

9 GRAPHICS CARD INSTALLATION

WITH THAT SORTED, we moved on to the graphics card. As standard, the graphics card mounting solution, rather bizarrely, runs the GPU with its backplate facing the window (we're guessing for better airflow). However, that doesn't make a whole lot of sense for a liquid-cooled waterblock that you want to display, so instead we had to flip it—to do this, you need to remove the GPU bracket entirely. It's mounted on the back of the motherboard tray with a couple of screws. So, take it out, flip it upside down, remount it, and you'll be good to go.



10 THE PERFECT FIX

SO, FITTINGS IN, let's crack on with the tubing. This is what we ended up with for the reservoir and pump setup. As you can see, the pump is still gravity-fed (though you do need to get past that center fountain tube in the res first). It flows down and around into the bottom radiator, and then up into the 240mm radiator, where it then goes around the back into the graphics card, through the block, around the top of the case, down into the CPU, and then back into the reservoir to repeat the cycle again. At least, that's the plan. We love the look of the frosted tubing here. Alphacool really has nailed it with this stuff, and with the pastel pink coolant as well, this stuff will shine. The only downside? There are no LEDs in that pump, and it could really use some.

11 FINISHED FRONT SIDE

THIS IS A GOOD SIDE-ON SHOT of where we were heading with the tubing design at this point. And if you're thinking, "But you always said a single 90 bend is best," yeah, you'd be right—that tube connecting the reservoir and the CPU is a stroke of luck. Getting the angle right was the hard part, because you've got one straight 90, then a separate one going to the reservoir. Fortunately, we were saved by fittings. There's a snakehead on the CPU portion, and two 90s on the reservoir that allow us to adjust the angles by just enough so that even if we're out with the length or where the bends are positioned, we can readjust the fittings to compensate.

12 I/O PASS-THROUGH

ON TO MORE DUAL-BEND TUBING RUNS—this was the hardest to get right. We cut through the I/O grille at the top and attached a pass-through. Bizarrely, it had one side longer than the other, so we used the clean side on the top of the case, near the I/O, and the threaded side near the CPU, because the top panel wouldn't close once a 90-degree fitting was attached, as it came into contact with the power switch. So, we rotated the fitting, which gave us enough clearance. The tubing run is not as straight as this photo makes you think, but it bends nicely, then provides a clean line to the graphics card. It took a few attempts to get right, but it does the job perfectly, although installing I/O cables was a heart-wrenching moment, as they had to slide beneath the tubing.

13 GRAPHICS CARD DISPLAY

WITH THE TUBING COMPLETE, the cables plugged in, and the coolant power-cycled, the build was complete. We did a quick and dirty install of Windows to configure the RGB lighting, and it looks really good. The graphics card, in particular, with its integrated LED lighting, really pops. We set it to white, to make it shine, as it highlights everything else without submerging it all in pink. There's a little air bubble, but over time it will move to the reservoir, and we can replace it with some good coolant. This build wasn't as seamless as you'd think, though, as we'd forgotten to tighten the two plugs on the other side of the GPU block, and coolant dripped on to the PCIe power connectors, which was as terrifying as it sounds. But after it dried out, it worked flawlessly.

14 RESERVOIR GLOW

HERE WE HAVE A FINAL showpiece shot, showing off the Alphacool reservoir. It's filled with Mayhems Pink Pastel coolant, and illuminated by means of the LED ring situated at the bottom. You can move that up and down, depending on what you want, and the light will shine out in both directions. It's quite effective, but we've decided we prefer it located at the bottom, just so it illuminates upward in that cool gradient glow. As well as that, we've also kept the ROG logo on the backplate of the GPU red. It's actually picking up a little of the light from the pink coolant, too, which gives it that edgy pink-red gradient effect as well.

BUILDING COMPLETE

THIS IS A SPECIAL BUILD for a number of reasons, not only because it's Zak's first build since his return to the magazine, but also because it's pink. And there's a story behind that, as there often is with these systems. In short, Zak asked his significant other what color she thought the coolant should be, and she replied, "Pink!" Not because she's female, but because it's one of her favorite colors. And, to be honest, we were more than happy to oblige. Reason being, in the publishing industry, especially in the technology sector, pink is seen as a feminine color, and management doesn't really like it. After all, the majority of our audience is male. Because of that, we've always had an in-joke among the team that it's secretly a hyper-masculine color, and should therefore be called MANgenta. Because, in our eyes, the fact that management thinks it's not manly makes us think it is. In fact, during Zak's original tenure on the magazine, he threatened the erstwhile executive editor, Alan Dexter, multiple times with making a pink liquid-cooled PC, because that was the only way to get mangenta on the cover.

That said, after this was built, the pink really does work quite nicely. Combined with the white lighting thrown out by the various LEDs situated across the components, it really does make the machine pop. In fact, it's one of our all-time favorite builds. Aesthetics aside, it's not perfect—it has some serious problems. Some that stem from building a show build like this, others due to overlooking stuff from a thermal perspective. It is way too hot; even with no overclocks, the system traps heat after two or three hours, and the fans ramp up anyway, negating a lot of the benefits you find from liquid cooling. The stock Phanteks fans we picked weren't sufficient, and ideally should be replaced with Noctua NF-F12s, Corsair ML120 Pros, or EK-Vardar fans. Something with high static pressure and low noise. Alternately, if Phanteks releases a mesh variant case, as it has done with the smaller Evolv Shift model, that may help, too.

It could also use some custom cables made to length specifically for it, because the Corsair Pro ones, although a fantastic kit, add far too much bulk to the cable-management space. And then there's the show-build element. With most of the liquid-cooled systems we build for the magazine, they have to be put together quickly, considering aesthetics above all else. That means there is usually only one fill port on a build. For long-term use, you need a drain port at the lowest point, too, because it makes it far easier to maintain your loop. We're using Mayhems coolant here, which is particularly long-life, but if we wanted to swap that out, it would be a real pain.

Build process aside, it's a fairly solid PC for living-room gaming. It's not a seamless experience, though. To get it set up properly, you need a standard install of Windows with a local account and no password. Then it's a case of configuring Steam to open in Big Picture Mode on startup, at which point you have access to your entire library. In fact, you can even link Uplay and other titles with Steam, too, although you need a keyboard and mouse handy from time to time.

Ultimately, our Pink Pariah is a gorgeous showpiece that can manage gaming at 4K, unhindered by any game you throw at it (with a little tweaking, of course), and it's more than ideal for your living room. Expensive? Yes. Very. And you could achieve something similar for half the cost. But, hey, then it wouldn't be pink.

1 **There's actually a Phanteks branded magnetic cable cover that goes across here, but with the 24-pin cables in place, it was easier to remove it than secure it.**

2 **We had to use a fan splitter cable here, because the motherboard only has three fan headers, and we have a total of four fans in the build.**

3 **We've also not plugged in the front USB 3.0 header for these two ports, because there's simply not enough space for them up there.**

4 **This is our rudimentary fill port: just an angled 90-degree fitting and a plug. It's simple and easy, and means we can perform coolant maintenance when necessary.**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,701	1,320 (-22%)
CrystalDisk QD32 Sequential Read (MB/s)	3,522	3,438 (-2%)
CrystalDisk QD32 Sequential Write (MB/s)	2,237	2,955 (32%)
Middle Earth: Shadow of War (fps)	56	49 (-13%)
Total War: Warhammer II (fps)	44	38 (-14%)
Assassin's Creed Odyssey (fps)	35	32 (-9%)
3DMark: Fire Strike (Index)	22,503	19,597 (-13%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i7-8086K @ 5.3GHz, 32GB Kingston HyperX Predator DDR4 @ 3,200MT/s, an Asus GeForce RTX 2080 Ti Turbo, and a 512GB Samsung 970 Pro M.2 PCIe SSD. All tests were performed at 4K at the highest graphical profile.

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REVIEWS

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ASUS HURACAN G21 PAGE 64

Asus Huracan G21

A subdued, tiny powerhouse that can go toe-to-toe with any "normal-sized," high-end rig

ANY MINI-ITX FORM FACTOR could be hiding an RTX 2080 beneath its slim case, and the Asus Huracan G21 is no exception. Its recent refresh puts it in a dead heat with other PCs of the same caliber; it can be configured with up to an Intel Core i9-9900K CPU and GeForce RTX 2080 GPU, which is the model we have here. If you're looking for a small PC that can handle the most demanding games, the Huracan G21 stands tall with the competition.

The all-black design gives this tiny tower of terror a minimalist look—but with a multifunctional twist. A flap on the right side panel folds up to expose the hardware inside, but it's not just there for show; the space within the geometrical design is empty, to allow extra hot air to escape. With the flap closed, the PC still stays cool, thanks to the efficiency with which the Huracan G21 dumps hot air out the back. It's noisier than its small-form counterparts, but you don't have to worry about it overheating.

There are nine USB ports: six on the back and three on the front, one of which is a USB-C port, so enough for all your peripherals. There's also a door on top that lifts up for easy access to a hot-swap 2.5-inch SSD drive bay, and something from ancient times called an optical drive nestled into the grooves of the left side of the case. Optical drives are basically obsolete, and the majority of modern cases don't include a bay for them, but this one blends in with the rest of the chassis, so it still looks nice.

If cable management outside your PC is a priority, you might be annoyed by the adapters used to power this PC instead of the usual PSU. Like Asus's higher-end monitors, the Huracan G21 comes with two chunky bricks for 280W power adapters. One of the appeals of small-form-factor PCs is that they are light and mobile; the Huracan G21 is light, but being tethered by two power adapters makes it more of a headache to move around.

Putting the Huracan G21 through our usual benchmark suite proved it to be a tough little machine. The Core i9-9900K averaged a multicore score of 2,000 (200 single-core) in Cinebench R15 at a boost clock of 4.6GHz—and the RTX 2080 did some work in 3D Mark, averaging 22,330 (1080p), 11,900 (1440p), and 6,210 (4K). But in-game benchmarks are where the real performance is at. The RTX 2080 averaged 106fps in *The Division 2*, 104fps in *Total War: Warhammer II*, and 78fps in *Metro Exodus* with graphics set to ultra. It performs well at 1440p on ultra, too, averaging in the mid-70s for *Division 2* and *Total War: Warhammer 2*, and the mid-60s for *Metro Exodus*. It struggled at 4K, but there's good news for ray-tracing fans: You can average just above 60fps at 1440p with ray tracing on high.

The sole let-down hardware-wise is the 1TB SSD, which only spat out average sequential read/write speeds of 1.5Gb/s and 1.7Gb/s—still fast compared to SATA SSDs, but not the fastest thing out there. At least the components are easily accessible, so you can swap that out for something faster, and it does come with 32GB of DDR4 2666 RAM, so you're future-proofed there.

Like other small-form-factor pre-builts, the Asus Huracan G21 does not come cheap—$2,800 for this fully decked-out configuration. That's cheaper than the likes of Corsair's One i165 (which retails at $3,500), but more expensive than MSI's Trident X (which is now retailing for under $2,000, and also comes with secondary storage and is quieter). When you weigh the cost versus the components in the Huracan G21, you're paying for all those extras: the cool magnetic flap, the aggressive angles, the hot-swap SSD bay, the warranty, and all the time saved from not having to squeeze your hands into a Mini-ITX case yourself. **–JOANNA NELIUS**

VERDICT **8**

Asus Huracan G21

CATEGORY 5 Good airflow and cooling; stylish; small form factor; impressive spec.

BREEZY Single 1TB SSD; uses two power bricks; pricey.

$2,800, www.asus.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	2,000 (-8%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	1,535 (-51%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	1,767 (-17%)
3DMark: Fire Strike Ultra (Index)	6,988	6,210 (-11%)
Total War: Warhammer II (fps)	42	43 (2%)
Tom Clancy's The Division 2 (fps)	38	40 (5%)
Metro Exodus (fps)	37	38 (3%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point consists of an Intel Core i9-7900X, 32GB of G. Skill Ripjaws V @ 3,000, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro M.2 PCIe SSD. All tests were performed at 4K at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i9-9900K
Graphics	Nvidia GeForce RTX 2080 8GB
RAM	32GB DDR4-2666
Motherboard	Z390 chipset
Storage	1TB SSD
Cooling Solution	Air
PSU	2x 280W power adapters
Case	Huracan G21
Warranty	Three years

Go, little PC, go!

The tiny touchscreen takes some getting used to, but can be useful.

Asus ZenBook Flip 15

It's chunky and it's weird, but we're still intrigued

THE LATEST ZenBook Flip is strange. It has a 10th-gen Intel CPU, but still uses the compact Max-Q version of Nvidia's GTX 1050, a two-year-old graphics card. It's got a 360-degree hinge, but it's thicker than any convertible we've seen recently. The trackpad doubles as a tiny screen with numeric keypad functionality, but Asus still saw fit to squeeze a physical numpad on the keyboard.

It's an odd, anachronistic product, as full of older hardware as it is brimming with innovation. The chassis is fairly bulky, with a 15.6-inch screen making the overall build a lot larger than sleek convertibles such as the HP Spectre x360 and the Dell XPS 2-in-1. It's not heavy, mostly due to the plastic chassis, but it does feel chunky and outdated.

That 360-degree hinge is a lot sturdier than the plastic outer shell suggests, raising the keyboard slightly toward the user in laptop mode and ensuring minimal movement when using the Flip 15 in other configurations. The keyboard doesn't share the same robust construction, though, with some keys making the entire plastic assembly flex alarmingly. The backlighting also isn't very impressive.

The trackpad, on the other hand, is a work of genuine beauty. It's the same ScreenPad Asus has been touting for a while, but upgraded to the ScreenPad 2.0: a dinky display that contains customizable quick-access apps, from a digital numpad to handwriting tools and Spotify. It runs up to 1080p 60Hz, but the default 1000x500 makes touch controls easier. Using an external mouse is a good idea to free up the ScreenPad, but it shifts back to trackpad use with a single icon tap, and feels good to use; it's wide, and has a robust click.

The Flip 15 is also equipped with an excellent display, a 4K panel with 10-point touch control. It's vibrant, with great color density, and makes using the Flip 15 in tablet mode delightful. It's larger and heavier than most tablets, which means holding it up isn't too comfortable, but it's perfect for a Netflix binge in bed.

Despite some peculiar design choices, the Flip 15 does perform OK. Most games are playable above 30fps at 1080p Medium or High settings, with less demanding titles such as *Fortnite* running great. This is no gaming laptop, but the GTX 1050 does put in the work, outpacing integrated graphics; the Flip 15 definitely meets the needs of casual gamers.

So it handles graphics well, but it falls down in other areas; CPU performance wasn't terrible but wasn't impressive either, while SSD read/write times were disappointingly slow compared to other recent laptops. The device as a whole isn't particularly well equipped for handling heavy video editing and 3D rendering tasks, but it's capable enough. The battery life is decent, although the discrete GPU and ScreenPad 2.0 definitely hamper it. In terms of overall performance, we'd say that we were thoroughly whelmed.

So, we can't outright recommend the ZenBook Flip 15 from a performance standpoint, especially not when it costs a hefty $1,550. Thankfully, it's bringing more to the table than just a GPU from 2018 and last-gen memory. The big, beautiful display makes this one of the best laptops around for watching video content, and the ScreenPad 2.0 is well implemented. It certainly has its uses, whether it's displaying tools for Microsoft Office or keeping music under control.

Speaking of music, the Flip 15 has a surprisingly good set of speakers. Anyone working with sound professionally will still want to use headphones, of course, but the Harman Kardon audio is genuinely good, handling both music and dialogue well. Connectivity is another area where the Flip 15 excels, as it boasts two USB-A ports, a USB-C port, headphone jack, SD card reader, and an HDMI port for connecting a second screen.

As is often the case with laptops, what you see is not what you get. On the surface, the ZenBook Flip 15 is pretty awesome—an excellent screen with a tiny bezel, funky trackpad display, and two-in-one functionality all seem like the perfect ingredients for a great laptop. But unless you're particularly drawn to the innovations on display here, there are definitely superior systems out there for the same price. **–CHRISTIAN GUYTON**

VERDICT 7

Asus ZenBook Flip 15

ZEN GARDEN Gorgeous 4K touchscreen; well-implemented trackpad display; good sound quality.

LANDFILL Sub-par keyboard; some outdated hardware; slow SSD.

$1,550, http://asus.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	561	758 (35%)
CrystalDisk QD32 Sequential Read (MB/s)	3,100	1,644 (-47%)
CrystalDisk QD32 Sequential Write (MB/s)	557	879 (58%)
3DMark: Fire Strike (Index)	1,062	5,167 (387%)
Rise of the Tomb Raider (fps)	5	27 (440%)
PCMark 8 (index)	2,543	3,250 (28%)
Battery Life: Movie Playback (Minutes)	840	620 (-26%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our notebook zero-point is the HP Spectre X360, with an Intel Core i7-8565U, integrated Intel UHD Graphics 620, and 8GB of DDR4-2400. *Rise of the Tomb Raider* is tested at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-10510U
Graphics	Nvidia GeForce GTX 1050 Max-Q
RAM	16GB LPDDR3 @ 2,133MHz
Screen	15.6-inch 4K IPS (3840x2400)
Storage	1TB PCIe NVMe SSD
Keyboard	Island-style backlit
Battery	Four-cell 57Wh
PSU	120W power adapter
Weight	4.2lb
OS	Windows 10 Home 64-bit

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AMD Athlon 3000G

Budget just got better

FIFTY BUCKS for an unlocked Zen-architecture processor with integrated graphics? Fifty bucks?! We wondered if AMD was joking when it announced the Athlon 3000G, but no; here it is, in all its super-affordable glory. Releasing a dual-core processor in the year 2020 feels like an odd move, but when it's cheap as all heck, it's certainly hard to argue with AMD's logic.

Team Red has long been the king of budget APUs, with the excellent 3400G and 3200G launching in its Ryzen line last year to some success. The Athlon 3000G isn't so much a step forward as it is a nimble leap sideways, filling a space in the market with a budget APU that sits alongside the likes of the Athlon 200GE. It's cheaper than the GE-series Athlon CPUs right now, too.

While this chip is 3.5GHz dual-core, it uses simultaneous multithreading tech to provide four threads, improving performance in some areas. It's also got three GPU cores (AMD's Radeon Vega 3 integrated graphics), and a super-low 35W thermal power design. CPU-savvy readers might recognize these specs as matching the older Athlon 240GE, and you'd be right; this is essentially the same chip, but unlocked for overclocking.

On paper, it's a huge improvement. It's a simple, affordable APU, ideal for low-powered systems that won't be doing much more than word processing and web browsing. The low TDP and dinky included cooler also serve this ideal; this isn't a CPU to pair with high-end components. Only eight PCIe lanes mean that using a GPU at all isn't ideal; performance is guaranteed to suffer compared to chips with more lanes. The low price means that pairing the 3000G with a GPU doesn't make much sense anyway, unless you have an old card lying around. Cheaper B450 and X470 motherboards with graphical outputs are the best companion to this chip.

The Vega 3 graphics are, well, fine. Running general desktop tasks on integrated saw little to no slowdown at 1440p and below, but running Win 10 at 4K was choppy and the available resolutions were oddly limited. AMD was keen to market this as a budget chip great for running esports games at 720p, but in practice it's only just capable of that. 2D indie titles should run fine, and we did manage to squeeze 30fps out of *Fortnite* on 720p Low settings, but the 3000G definitely isn't the poster child for gaming on integrated graphics.

Just two cores means that the 3000G isn't equipped to handle rendering tasks, either, despite SMT doubling the thread count. Our benchmarks took so long to run, we could feel our beards growing as we waited for them to complete. The figures weren't very impressive either, but were more or less what we expected; the 3000G performs about as well as the 240GE, albeit with added overclocking headroom (because the 240GE had none).

Overclocking does help, with a stable overclock of 4.1GHz easily achievable. 4.2GHz will likely be an option for some chips, but you're beholden to the silicon lottery. Running the CPU at 4.1GHz got us about 15 percent improved performance on average across all our tests—impressive considering how easy overclocking was. The chip did heat up to the mid-60s; we wouldn't advise using the puny stock cooler if you're overclocking.

At the time of writing, the 3000G is selling fast. While the RRP is $50, the chip is sold out in many retailers, and we couldn't find it for under $55. Still a great deal; the cheapest we could find the comparable Athlon 240GE was $70. The 3000G effectively replaces the 240GE in the Athlon hierarchy; it's the new dream chip for budget and low-power rigs, ideal for entry-level builders and experienced overclockers looking to build a PC for peanuts. **–CHRISTIAN GUYTON**

BENCHMARKS

	AMD Athlon 240GE	AMD Athlon 3000G	AMD Athlon 3000G @ 4.1GHz
Blender 2.82 Beta BMW (pps)	536	531	**598**
Cinebench R15 Single/Multi (Index)	142/394	142/398	**169/460**
POV-Ray 3.7.1 Single/Multi (pps)	339/873	341/856	**467/1,036**
PCMark 8 (Index)	3,198	3,232	**3,432**
AIDA64 Latency (ns)	75	75	**71**
AIDA64 Memory Bandwidth (MB/s)	44,860	44,711	**45,083**
Tech ARP's X264 (Avg fps)	8.75	8.84	**10.39**
Total War: Warhammer II (fps)	**5**	**5**	**5**

Best scores are in bold. Our test bed consists of an Asus ROG Strix X470-F Gaming, 32GB of Corsair Vengeance RGB Pro DDR4-3200, an ADATA SU630 512GB SATAIII SSD, and a Be Quiet! Dark Power Pro 1200W. All games are tested at their highest graphical profile at 1080p.

VERDICT **8**

AMD Athlon 3000G

DECATHLON Stupidly cheap; very low power draw; Vega 3 graphics are decent.

EXHAUSTION Poor rendering performance; limited PCIe lanes; included cooler is weak.

$55, http://amd.com

SPECIFICATIONS

Base Clock	3.5GHz
Cores/Threads	2/4
Lithography	14nm
Cache	4MB L3
Memory Support	DDR4-2667
Memory Channels	2
Max PCIe Lanes	8
Graphics	Radeon Vega 3
TDP	35W

HP Z38c

HP's ultrawide workhorse is an intriguing 4K alternative

THE EASY CHOICE for blowing a big monitor budget? Bag a 4K model. It's also the unimaginative option. Enter the HP Z38C, an intriguing alternative to the 4K norm, with its 21:9 aspect ratio and generous 38-inch diagonal.

What it's not, however, is necessarily superior to a conventional 4K monitor, nor is it the first of its kind. It was early 2017 when LG rolled out the first 21:9 aspect 38-inch monitor, the 38UC99, and set the precedent for the HP's 3840x1600 resolution. As it happens, HP's IPS panel is almost certainly produced by LG. More importantly, it offers fewer overall pixels than a standard 4K monitor. Full 4K works out to nearly 8.3 million pixels. The HP's cut-down vertical resolution compared to 4K results in just over 6.1 million.

The bottom line is that while the HP Z38c makes for an interesting ergonomic alternative, thanks to its wide aspect, curved panel, and large proportions, you're not getting particularly impressive pixel density at just over 109dpi. That's unexciting, especially at this price.

If it's not sharpness and detail that the Z38c majors on, then what? Strictly speaking, it's not cutting-edge visuals either. HDR support is notable by its absence, there's no local backlight dimming, nor high refresh rate support. This is an SDR, 60Hz experience from a monitor merely capable of 98 percent of the sRGB gamut. HP makes no further claims for Adobe RGB or DCI-P3 spaces.

HP's Z31x Studio Display is quoted at 100 percent of both sRGB and Adobe RGB, and claimed to be good for 99 percent of DCI-P3. The Z31x is, of course, more expensive, but its superior color capabilities highlight that the Z38c isn't intended to be a content creation display. It's a general productivity device.

In that regard, it has lots to offer. The panel size and proportions are superb for viewing multiple documents and webpages in parallel. Anything up to four windows situated horizontally works well. To that it adds USB-C connectivity with charging support up to 65W. The upshot is the ability to connect compatible laptop PCs to the HP, and not only drive the display and charge the laptop at the same time, but also connect peripherals.

Once you've tried this kind of single-cable docking, you won't want to go back to that old rat's nest of cables. However, DisplayPort and HDMI connectivity are provided separately, ensuring all options are covered. This is also a beautifully built display. It looks and feels very nicely engineered. Adjustments include tilt, height, and swivel. You can't rotate it into portrait mode, but given the ultrawide aspect and curvature, that's no surprise.

As for image quality, it's in line with expectations. This is a nice, rather than stellar, IPS panel, with natural colors and good viewing angles. Contrast is merely adequate. Gaming is not really within the Z38c's remit, but as 60Hz monitors go, it's still pretty special. You wouldn't choose it for hair-trigger shooters, due to the limited refresh, but the pixel response is decent, and there's no discernible input lag, so it'll turn its hand to first-person adventure titles, driving sims, strategy games, and more. Everything looks fantastic on the big, wide-aspect panel.

All of which means the HP Z38c is a very nice all-arounder, accepting certain caveats. It lacks the color fidelity for pro-level content creation. It's not HDR capable. The 60Hz refresh limits its appeal to serious gamers. And the mediocre pixel density is a deal-breaker for anyone who demands an Apple Retina-style experience. But as a productivity workhorse with great connectivity and some decent gaming chops, it's a very nice package. –**JEREMY LAIRD**

VERDICT **7**

HP Z38c

PIXEL PERFECTION Fantastic productivity machine; gorgeous build quality.

PRACTICALLY PROSAIC Mediocre pixel pitch; old-school image quality; price.

$999, www.hp.com

SPECIFICATIONS

Panel Size	37.5-inch
Panel Type	IPS
Resolution	3840x1600
Brightness	300cd/m^2
Contrast	1,000:1
Pixel Response	14ms (on-off)
Refresh Rate	60Hz
VESA	100 x 100mm
Inputs	DisplayPort 1.2, HDMI 2.0, USB C

USB-C and fantastic build quality add to the Z38c's productivity appeal.

Razer Basilisk Ultimate

Razer's flagship FPS mouse cuts the cord

SITTING ON its charging stand like the sought-after artifact on a pedestal in an Indiana Jones movie, this Basilisk Ultimate certainly has the looks. This is a wireless gaming pointer with no expense spared, from the 20,000dpi sensor and 100-hour battery life to the RGB dock, the luxurious materials forming the body around it, and a host of subtle design touches that all combine to make life a little easier.

It's a gorgeous mouse. While the standard Basilisk model is bogged down in unsightly grooves along its inner side panel, this features a textured, rubberized finish at either side, which functionally improves grip and aesthetically preserves a clean, professional look.

Only the asymmetrical ergonomic shape jumps out as an obvious through-line between Basilisk models, in fact. It's a body best used in palm grip, but also comfortable in claw or fingertip style—though not quite as naturally suited to the latter as smaller ambidextrous models such as Razer's own Viper Mini, the Zowie FK2, or the Glorious Model O Minus.

Forward and back buttons sit perfectly integrated into the lines of the left-hand side, and further toward the front sits a removable DPI clutch, ready to kill your sensitivity when you need total precision in FPS games. If you don't like the sound of that, a rubber stay can be plugged in instead.

Elsewhere, there's a pair of DPI switches to cycle between up to five modes on the fly, a mouse wheel with two additional inputs by nudging it sideways left and right, and two beautifully scalloped oversized mouse buttons covering Razer's mechanical switches. If you have any reservations about dropping this much dollar on a mouse, its appearance alone will assuage them.

We just wish it was easier to play competitive shooters with. This being a wireless model, it just can't look wired mice in the eye when it comes to response time, and has an almost ethereal "feel" when you're in game. Yes, the wireless receiver is subtly elegant, as much as a small lump of plastic can be, and yes, it's nice that there's a recess on the underside of the mouse for storing the receiver when you take your setup on the road. But when the bomb's down on A, and you're 1v5 with low HP, you'd trade it all for a simple cord. Razer says its own wireless tech is 25 percent faster than any of its rivals, but there are still occasional moments of noticeable dropout or latency.

DAMAGE LIMITATION

Maybe it's the wireless, the weight, the small PTFE feet, or some combination of all of them, but we actually noticed a consistent drop in K:D when using this versus a wired Viper in *CSGO*. So, sadly, it's not ideal for your competitive shooter of choice where marginal gains matter. In that setting, Razer's much cheaper Viper Mini is a better pick, benefitting from massive and super-smooth PTFE feet and a super-light 68g total weight, which combine beautifully when you're making big movements across the mouse mat—especially important for low-DPI players.

Where the Basilisk Ultimate does shine, though, is in, well, everything else. Offline shooters, strategy games, workstation use, whatever you generally click in day-to-day life, it all feels a bit more luxurious with this under your hand. Ultimately, the high-end peripheral market is about treating yourself more than seeing tangible benefits in gaming performance or functionality, and in the field of treating yourself, Razer is king.

Enter the RGB options and feature-rich (to the point of bloated) software. Both the mouse and dock are fully customizable, the former over 14 individual zones via the Chroma app. Synapse, the meat-and-potatoes software component, allows for DPI tweaks and button behavior mapping. Having to create an account (and thus share social media or email details with Razer) is a drag, but you can't knock the functionality.

It's a heart over head purchase, then. It might not be esports-grade in performance, but the look and feel are very seductive. **–PHIL IWANIUK**

VERDICT **8**

Razer Basilisk Ultimate

RAZER THE BAR Supremely comfortable; wireless charging dock; looks magnificent.

LISKY BUSINESS Not for competitive FPS.

$220, www.razer.com

SPECIFICATIONS

Sensor Type	Optical
Sensitivity	20,00cpi
Programmable Buttons	11
Battery Life	Up to 100 hours
Lighting	14 RGB zones
Dimensions	130mm/5.11 inches (length) x 60mm/ 2.36 inches (grip width) x 42mm/1.65 inches (height)

Asus ROG Delta White Edition

Premium cans with a hi-fi grade DAC and luxurious looks

IF YOU CAN COUNT on one thing from Asus's headset line, it's the unexpected. There's a swashbuckling approach to its gaming cans that's unlike any of its rivals, characterized by confusing subdivisions of Republic of Gamers (ROG) models and The Ultimate Force (TUF) options, which represent a premium and budget split.

These ROG Deltas feature a totally different design from ROG's flagship Centurion cans, and differ completely from the TUF Gaming H7s and H5s, too—which are also dramatically different from each other. Perhaps it's unfair to take from this that Asus is still searching for that one killer headset design, whereas SteelSeries bases all models around the Arctis, and Razer iterates on a couple of basic shapes (the Nari and Kraken).

Whether there's any truth to that or not, this luxuriously specced Delta White Edition proves just such a killer design. Broadly comparable to Corsair's VOID shape, the earcups sit nice and tight around your ear, creating a chamber for the bass to resonate within, while very generous memory foam pads in protein leather finish keep the sensation soft and, for want of a better word, "premium."

The finish is the stuff of $250-plus headsets all over, from its noiseless joints to the slightly pearlescent white finish on the earcups and brackets. The RGB lighting is among the best we've ever seen, too—its default pattern is an array of tastefully paired color combinations, which look razor sharp around the outer edge and ROG logos. The headband itself could do with a bit more padding underneath, though, as it can dig in after a while and become uncomfortable—perhaps a broader band would solve it.

In a characteristic twist, this model features not only a native USB-C connection in the name of multiplatform support, but virtual surround, too (thankfully optional and disabled by default), and also an ESS 9218 quad DAC capable of 24-bit, 96kHz audio. In other words, it sounds clear as all heck and you can use it with your smartphone and consoles without swearing at a pile of cable adapters.

Throwing in a hi-fi grade DAC doesn't guarantee great sound across the board, though, and as is so often the case, the 50mm drivers in this headset have been tuned for a scooped EQ response. And that's great for picking out high frequencies in games or listening to late '80s thrash metal, but with warmer-sounding sources, such as singer-songwriters and melancholic indie adventure games, that harshness becomes obvious.

So, the benefits of a great DAC are muted slightly by the EQ tuning and, as ever, it's not possible to simply load up the Asus Armoury app and tweak it back to a flat response using software sliders—this is a hardwired response, and it can't be undone at a software level.

Which means—and we really should set up a macro on our keyboard for this—although the headset sounds suitably bombastic and dramatic in games, its scooped EQ means it's not versatile enough for use as a "one solution" headset with your phone, too. Podcasts and music just don't have the warmth or sparkle that they ought to—and, indeed, could, given the DAC involved.

Still, this model is a net win for Asus, which has demonstrated beyond a shadow of a doubt it can put together a truly luxurious set of cans that, although pricey, feel much more expensive than they are. Even the mic is surprisingly clear and full-bodied, and Asus's Armoury has handy boost and clarity functions for even better Discord squabbles. It's just one iteration from being a real no-brainer in the wired market, but as it stands, the headband discomfort and V-shaped EQ response hold back an otherwise preposterously well-specced package. **–PHIL IWANIUK**

VERDICT **8**

Asus ROG Delta White Edition

WHITE KNIGHT Hi-res ESS quad DAC; superb RGB effects; easy multiplatform support.

ROG BOTTOM Drivers are over-tuned; comfort issues.

$150, www.asus.com

SPECIFICATIONS

Driver Size	50mm
Frequency Response Range	20Hz–40kHz
Impedance	32 ohms
Weight	13.7oz
Connection Type	USB-C
Lighting	Customizable RGB

Asus ROG Pugio II

A worthy successor to the previous best ambidextrous gaming mouse

THE FIRST ROG PUGIO was a pretty standard affair, a wired gaming mouse with a 7,200dpi optical sensor, RGB lighting, and an ambidextrous design that allowed both left and right-handed users to enjoy an ergonomic mouse experience. It was a decent mouse, although it didn't set the world on fire. Now, Asus is back with a new Republic of Gamers mouse, the ROG Pugio II, a wireless sequel to the original Pugio.

Now, calling this a wireless mouse is doing it something of a disservice. The Pugio II uses tri-mode connectivity, consisting of a 2.4GHz wireless USB dongle, Bluetooth 5.0, and wired connections using the included USB cable. The 2.4GHz connection means ultrafast wireless, with zero noticeable input latency in our tests.

The dongle in question can be concealed inside the mouse for portability, as the plastic rear cover of the mouse is held in place magnetically and can be easily lifted off. This also allows access to the screws that hold the two main buttons in place, because the Omron switches beneath can be swapped out (or replaced) using an included tool.

Externally, the design is clean and simple, with a symmetrical button layout that consists of two small buttons on either side of the mouse. These can be deactivated using the ROG Armory software, or removed entirely thanks to snap-off magnetic button caps, making it easy to avoid accidental clicks.

The Pugio II has actually lost a programmable button from its predecessor, which is a definite shame; the DPI adjustment button is also found on the underside of the mouse, which is less than ideal if you're seeking on-the-fly sensitivity tweaking. This button does have two modes, however; click once to cycle between presets, or click and hold to use the scroll wheel for more precise adjustments.

The RGB lighting is used to indicate DPI changes, and overall is actually quite good. RGB is spread over three zones—the scroll wheel, the ROG logo, and a raised base strip around the rear of the mouse—and can be customized using the ROG Armory software. The ROG logo can also be swapped out for custom plates, enabling you to show off your own designs, but this is an arduous and poorly explained process.

NO ARMORY AMOUR

Let's address the elephant in the room: ROG Armory isn't that great. The available options are somewhat limited, setup is time-consuming, and using the software for the first time required a complete system restart. Features are heavily limited when using a Bluetooth connection, too, which isn't ideal for tablet and notebook users.

We can't judge the Pugio II too harshly for this, though, because the 16,000dpi optical sensor does perform excellently. With up to 400ips and 40G acceleration, combined with the 2.4GHz wireless connection, the Pugio II feels precise and snappy to use. It weighs barely more than 3.5 ounces, and the ergonomic design makes it comfortable to use for hours on end.

A few other features from the original Pugio have made the jump to the second edition, too. Three on-board memory slots enable you to store configurations for lighting, sensitivity, or button layouts, meaning they can be instantly reacquired upon setting up the mouse on a new system—perfect for gamers on the go. We do wish the braided cable from the Pugio had returned as well, because the new included cable feels a bit cheap and rubbery. It also uses a shaped USB-C connector that matches the shaped port on the mouse, irritatingly precluding the use of third-party cables.

On the whole, though, the Pugio II is a solid all-around gaming mouse. It's still not really doing anything to set the world alight (although this southpaw reviewer is pleased to see a mouse for left-handed folk), but it performs well and has a comfortable, straightforward design. 2.4GHz connectivity is a boon for gamers chasing that perfect zero-latency experience, too. –CHRISTIAN GUYTON

VERDICT **8**

Asus ROG Pugio II

PUGILIST Comfortable, ambidextrous design; tri-mode connectivity; good RGB lighting.

PUGNANT Software isn't great; DPI button on base; included cable sucks.

$115, http://asus.com

SPECIFICATIONS

Sensor	Optical
Sensitivity	16,000dpi
Sensor Model	400ips
Polling Rate	1,000Hz (125Hz via Bluetooth)
Programmable Buttons	7
LEDs	3 RGB zones
Cable Length	6 feet
Weight	3.6oz

IOGEAR Kaliber Gaming HVER Pro X

Plenty of pros, but a few cons, too

LET'S HIT YOU with the first thing that hit us: The top plate of the HVER Pro X is pretty outrageous. It's a screwed-down aluminum slab that spills off all sides of the keyboard, as though it's desperate to escape. We'll say it: Those edges are really, desperately ugly, stamped and bent with xtreeem gamerz cuts and slashes that do more to take away from the look of the HVER Pro X than add to it. Aesthetics aside, they are at least practical—you can balance a pen on the rear lip, and the curves on the bottom and side edges make this more comfortable on the palms than some.

The top panel also aids in the Pro X's spill-proof design. We won't claim that the half can of Monster Energy that hit our review model was a deliberate test—ahem—but credit where it's due, this survived without an issue, which could be a big plus for those with busy desks. Weirdly, though, our review model, as shipped, seemed to be under a whole lot of tension. It would not sit flat on the desk, whether the feet were extended or not. The only way to remedy the situation was to grab the bottom-left and top-right corners of the top plate—which appears to be responsible for the Pro X's otherwise-commendable rigidity—and physically muscle the keyboard back into shape. That really is a new one.

There's more here that feels a little rinky-dink. Just focusing on the keycaps, the double injection process used to create the antiwear key markings means many characters are slightly truncated, like they've been stenciled on in a hurry by the A-Team; key bracing is passable at best, leaving the main bulk of the caps slightly wobbly, and larger keys positively floppy, with a cheap rattle, to boot; and most egregiously, the screen-printed top-of-key markings are slightly off-center, a tiny and insignificant thing that nonetheless made our teeth itch.

But perfection isn't why you're here. You're here because this is a paltry $90 keyboard picking a serious fight with some serious (and seriously expensive) competitors. With brown optical mechanical switches, it does indeed manage that delicious combination of tactility, quiet (mostly), and seat-of-your-pants responsiveness, with little in the way of inconsistency between different keys. It's fast, with the optical actuation just slightly below the tactile bite, which is right where it should be. Perfect for a stream, tight enough for games, adept at office and general desktop use; niggles aside, the HVER Pro X is a very capable mechanical keyboard.

PLEASANT REVOLT

Perhaps capable isn't the world. Maybe we'd stretch so far as pleasant, because it's surprising just how good this feels. There are better out there—Cherry MX Brown switches feel infinitesimally more pleasant than these generics, and those rattly, wobbly keys aren't going anywhere—but this kind of consistent and quick switch response is beyond rare at this price point. There's full N-key rollover and antighosting, too, which means nothing's been left on the table in terms of tech.

Also remarkable is the lighting, which is honestly toward the top end of what we'd expect from any RGB board at any price. Shine through the keycaps is, as you'd expect from a double injection process, very good, and the semi-gloss black finish of the brushed top panel gives enough glow without overdoing things. It's per-key RGB, with some strong effects, customizable in software (naturally), with three custom profiles mappable to three function keys.

This is a keyboard that works. It's solid, it does the job, and bits of it are truly impressive. But the HVER Pro X needs tightening up somehow—a little refinement in design, a bit of care and attention paid to the little things, perhaps even an extra $5 or $10 on the price tag, if that's what it takes, and this would be a real battler. **–ALEX COX**

VERDICT 7

IOGEAR Kaliber Gaming HVER Pro X

+ OPTICAL Spill-proof; decent switches; fantastic lighting options.

– CANOPTIC Rattly keys; some questionable style choices.

$90, http://iogear.com

SPECIFICATIONS

Switch Type	Brown, optical
Form Factor	Full size
Media Keys	With Fn
Macro Keys	Customizable
LEDs	Per-key RGB
N-Key Rollover	Yes, full keyboard
Pass-Through	None
Dimensions	1.2 x 7.1 x 18.4 inches
Warranty	Two years

BitFenix Dawn TG

Light it up

BITFENIX'S OFFICIAL description of the new Dawn TG case is a little... peculiar. It might be slam poetry. There's something in there about a "breeze of sunlight," whatever that is. It also mentions a "new era of renaissance" when it comes to case design aesthetics, and it actually might be right. The Dawn TG is surprisingly innovative, with some good ideas, and an appealing visual design that brings a lot of lighting without looking obnoxious.

Of course, the lighting is the main selling point. We're frequently skeptical of cases with integrated lighting beyond RGB fans, but BitFenix has come up with a solution that looks great without being complicated; a concealed lightstrip runs up the front corner of the case, shining through the diagonal patterns on the front and right-hand glass panels. It's understated and stylish.

There's a lot of cables in this case, which makes pairing the RGB lighting with your mobo for software control a hassle. Three fans means more cables, too, with two plain black fans at the front of the case and an RGB fan at the rear.

Fortunately, cable management in this chassis is nice and easy. The rear of the motherboard has plenty of anchor points for cable ties, and the cavity as a whole is quite deep, leaving enough room for thick PSU cables. There's also an inelegant but undeniably effective solution here: a large, solid metal plate that routes cables vertically, with open space either side. It's a little ugly, but invisible once the side panel is back in place, and it does a good job of keeping the I/O cables tidy (or at least hidden).

The motherboard mounts with plenty of space for a radiator and fans in the roof of the case, although it leaves little room at the bottom. With a power supply in place, two of the holes in the top of the PSU shroud are effectively blocked from use, which is frustrating. The shroud also conceals a drive cage, which is mounted a little too far back in our opinion; using a modular power supply with HDDs fitted will leave you precious little space to work with.

Speaking of the drive cage, it's a strange one. Rather than easily removable plastic brackets that slot into the cage, the whole cage must be removed, allowing for two hard drives to be screwed in; one inside the cage, and one on top. Elsewhere, there are two flat mounts—one behind the motherboard, and one on top of the PSU shroud. These clip into place and are held down with a single thumbscrew, allowing for either two SATA SSDs or one 3.5-inch HDD per mount. Unfortunately, they do rattle around somewhat, regardless of how firmly they are screwed down; we wouldn't really want to mount a full-size HDD on them.

In fairness to BitFenix, the Dawn TG does use thumbscrews where possible, making building in this case a pretty straightforward process. Cleaning the dust filters is also an easy undertaking—large filters on the front and base of the case slide out smoothly on rails, while the top of the case has a magnetic filter, which can be swapped out for a solid cover if you would prefer to have more directional airflow.

The front I/O supports USB-C as well as packing two USB-A ports and audio jacks. The buttons are somewhat tacky, made of cheap plastic; in fact, the whole steel frame feels flimsy in some areas, particularly the perforated roof and rear of the case. It's not ruinous, but given the $130 price tag, we do wish the case felt a little more robust.

There are a few innovative design choices on show here, such as the funky lighting patterns and a rear bracket for vertical GPU mounting, but on the whole, the Dawn TG feels relatively expensive for what you get, especially when BitFenix is already offering the Enso Mesh and Saber cases, which get you RGB case lighting but for under 100 bucks. In the end, this is a choice of aesthetics over value. If you like the Dawn's look, go for it; otherwise, you could spend your money better elsewhere. –CHRISTIAN GUYTON

VERDICT **7**

BitFenix Dawn TG

SUNRISE Excellent lighting; three tempered glass panels; good cable management.

SUNSET Buttons are cheap; metal frame feels flimsy; overpriced.

$130, http://bitfenix.com

SPECIFICATIONS

Form Factor	Mid tower
Motherboard Support	ATX, E-ATX, mATX, ITX
Colors Available	Black
Window Available	Yes
3.5-Inch Support	2+2
2.5-Inch Support:	4+2
Radiator Support	360mm front, 280mm roof, 120mm rear
Fan Support	3x 120mm front, 2x 120mm roof, 1x 120mm rear
Dimensions	8.7 x 19.1 x 17.7 inches
Graphics Card Clearance	15 inches

Lian Li PC-TU150

One briefcase please, hold the brief

LIAN LI HASN'T MADE a super-compact PC case with a carry handle in quite some time. The TU150 is a long-awaited follow-up to the classic TU100 and TU200 cases, which were released years ago and, frankly, were ugly as hell. Nobody wants their sweet portable gaming PC to look like a shell case for their ailing Fleetwood Mac cover band's solitary amplifier. If you disagree with that statement, put down this magazine, and go buy your bandmates another amp!

The TU150 is an altogether more tasteful affair, engineered for the best possible use of space, and crafted from aluminum and steel, with a tempered glass window or silver finish available at no extra cost, should that take your fancy. The panels pop off the TU150 with a little pressure, allowing for screwless disassembly. There's no RGB lighting to be found here—not even a tiny HDD activity LED—but the TU150 still looks significantly more attractive than its predecessors, like an armored briefcase containing nuclear launch codes or your grandmother's mac and cheese recipe.

The brushed aluminum front panel is topped with a simple front I/O, which has two USB-A 3.0 ports and a speedy USB-C 3.1 port, along with two 3.5mm jacks for a mic and headset, plus the power and reset buttons, of course. It's nothing to write home about, but it has all the usual features, and looks nice and snug tucked into a trapezoid slice in the metal casing.

We were worried that so much aluminum might make the TU150 feel flimsy, but it's anything but. Lian Li has brought its usual case construction chops to this design, with a solid steel frame underneath those brushed aluminum panels, ensuring that the entire case feels exceptionally robust. Even the carry handle, which now snaps down magnetically to sit flush with the roof of the case when not in use, is anchored directly to the frame. We wouldn't be worried to carry an expensive build around in this.

Lian Li's use of space inside the case is inspired, from a PSU adapter cable that routes along the top of the case to the stripped-back motherboard tray that allocates ample space for cable management. The power supply mounts to the upper-front of the case, which leaves plenty of room for a graphics card, although, unfortunately, you're limited to SFX and SFX-L power blocks.

There are two separate drive mounts, one for 2.5-inch SATA SSDs and one for either an SSD or 3.5-inch HDD. The latter sees your drive secured to the roof of the case, which looks a little strange but works well in the limited space.

COOL CASE

Cooling is an issue that frequently arises when it comes to ITX cases, but we're happy to say that the TU150 performs reasonably well in this area. There's a decent amount of clearance for the CPU cooler, especially for an ITX case, making this ideal for compact builders who still like a chunky air cooler. The case only takes 120mm fans (and comes with none as standard, so bear this in mind, should you be considering a purchase), allowing for one at the front and back, and potentially two in the floor of the case, as well.

There isn't much room down there at the bottom, though. If you want to use an AIO cooler, you're limited to a single 120mm radiator at either the front or back, and some bulkier GPUs will preclude the use of fans in the case floor. There's no included dust filter here either, which feels odd, given that the front fan mount is protected by a fine mesh shield. The case is well ventilated, with tall feet and tidy perforation on the base, rear, and sides, but that set off some alarm bells regarding dust being sucked in through the underside.

It's a minor concern that could be sorted out with a custom dust filter, so we can't mark the TU150 down too much. This is the best ITX case we've seen in a while, matching robust materials with a clean new design. At $110, it's sensibly priced for what you get, sitting in the same ballpark as ITX cases from Phanteks and NZXT, so we can't complain about the price either. The TU100 is dead; all hail the TU150! –CHRISTIAN GUYTON

VERDICT **9**

Lian Li PC-TU150

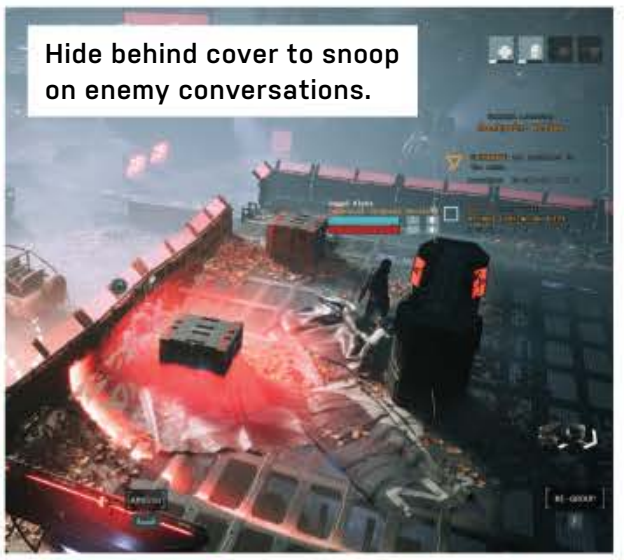
PORTABLE Extremely sturdy construction; great use of internal space; reasonably priced.

PORTA-POTTY Limited to smaller PSUs; no extra fans or dust filters included.

$110, http://lian-li.com

SPECIFICATIONS

Form Factor	Mini-ITX
Motherboard Support	Mini-ITX, Mini-DTX
Colors Available	Black, silver
Window Available	Yes
3.5-Inch Support	1
2.5-Inch Support	1+1
Radiator Support	120mm front/rear
Fan Support	1x 120mm front, 2x 120mm base, 1x 120mm rear
Dimensions	8.0 x 14.8 x 12.3 inches
Graphics Card Clearance	12.6 inches



STEALTH TACTICS GAME

Corruption 2029

No talking animals this time around

SWEDISH DEVELOPER The Bearded Ladies made a game a little while ago that was a mix of real-time stealth and turn-based tactics, in which you were heavily outnumbered by the enemy, and had to tune your approach to combat situations effectively. There was a duck in a top hat, a pig with a blunderbuss, and a sniper fox. You know the one.

With *Corruption 2029*, just over a year later, the same devs have released the same game, but without talking animals.

It's an unexpected and slightly bizarre release, which might perhaps make sense if it were framed as a prequel. In fact, you're given very little information about what's going on. The opening cinematics tell you more about your troops than the geopolitics, introducing them as drones stripped of their humanity. There's a distinct whiff of *Syndicate* or *XCOM* in the way they stomp around in their long flappy coats, giving the occasional glimpse of a robotic leg, but their large angular helmets set them apart. You act as their controller, using them to explore the ruined streets of America during a new civil war in real time, activating some sort of stealth cloak when you want to remain unseen. Getting spotted brings the entire map's worth of enemy soldiers down on your position, so it's worth putting off until the last possible moment.

Engaging enemy soldiers drops the game into a turn-based *XCOM* mode, with high and low cover, overwatch, and to-hit percentages. Apart from at the very start, you are always outnumbered, so attacking from ambush and whittling down enemy numbers using distractions and silenced weapons are a must. Get a lone trooper far enough from his buddies, and you can open up with all weapons without being heard, but gauging that distance is a fine art. Add to this the pathetic weakness of silenced weapons, and it's only the very basic enemy troops who go down easy.

Where it deviates more from the *XCOM* formula is in the lack of a strategic layer. You choose your missions and you play them, almost as if you were some sort of drone yourself. You pick up additional weapons and "implants," such as the ability to jump really high, along the way, doling them out to your squad of three. Nicely, there's no restriction on what weapon combos you can equip, so if you want two assault rifles, go for it. Ammunition is infinite, but magazines are small, leading to frequent reloading.

Corruption has a lot to like about it. The duck, pig, and fox brought personality to a world of decaying buildings and crashed planes, but the context of a war still being fought even though both sides have forgotten why means the *XCOM* mechanics make more sense. It helps that the game can be beautiful at times, with light slicing through autumnal trees and wonderful blue hexagonal domes popping up as you deploy an energy shield, although your viewpoint is maddeningly fixed in terms of height and angle.

A dev reusing so much of a previous game to make a new one may have been unexpected—the game has no official website, and even the developer's site doesn't mention it—but when it results in a fully refreshed title like this, sold for a budget price, it's very much the kind of thing we can get behind. **–IAN EVENDEN**

VERDICT **7**

Corruption 2029

DUCK Stealth tactics and ambushes are all the sweeter the second time around.

COVER Maps quickly repeat; reloading (both weapons and game) is a must.

RECOMMENDED SPECS Core i7-4771/AMD FX-9370; 8GB RAM; GTX 970/RX Vega 56.

$20, www.epicgames.com, ESRB: Not rated

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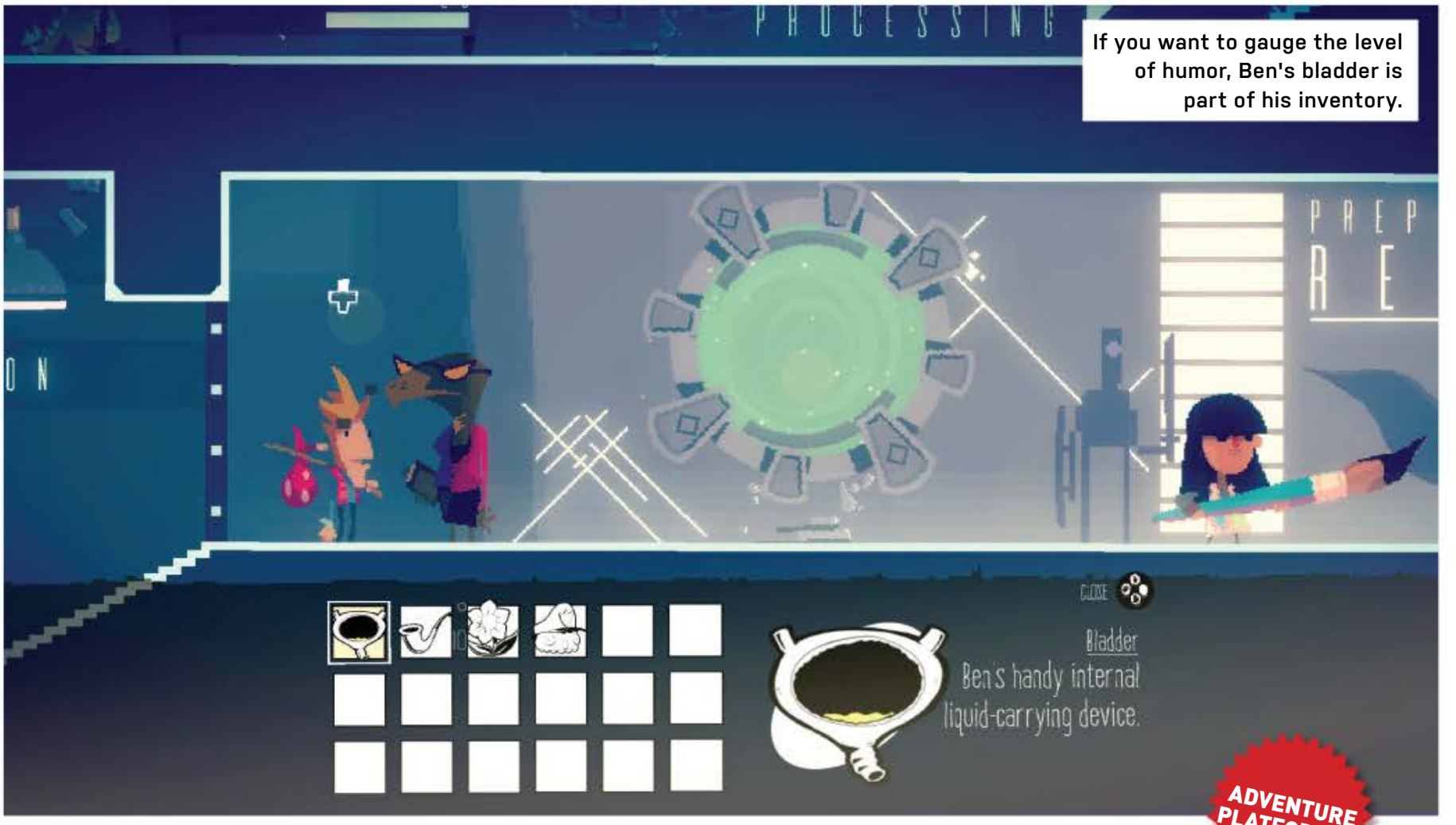
PROCESSING
If you want to gauge the level of humor, Ben's bladder is part of his inventory.
PREP
CLOSE
Bladder
Ben's handy internal liquid-carrying device.

ADVENTURE PLATFORMER

Lair of the Clockwork God

How appropriate, you platform like a cow

BEN AND DAN, dual protagonists of *Clockwork God,* have been through two games before, classic point-and-clickers in the LucasArts mold. This time around, though, while Ben sticks to following the pointer and combining objects with words, Dan has decided to reinvent himself as a character from a platform game.

Ben and Dan are also the names of the writers and developers of the game, and if you're a fan of fourth-wall-breaking, raised eyebrows, and ironic self-insertion, there's a lot of that here to please you, especially if you played a game in the '90s. Appropriately, despite its modern trappings, the game *Lair* most closely resembles is *The Lost Vikings* from 1993, in the way you switch between characters with differing abilities to solve puzzles.

Unlike other dual-protagonist games, such as *Kalimba,* however, Ben and Dan move independently and frequently interact. Their newly divergent natures, though, lead to a control system that's neither one thing nor the other—one character who favors mouse and keyboard, and another who's better suited to a gamepad. They're even drawn differently, with Ben's lankiness somehow appropriate for his role in using objects and turning levers, while Dan's more hunched appearance makes him look like Sonic charging up a spin attack.

VERBS AND PICTURES

What this means in practice is that while Ben can walk in straight lines and interact with objects and characters through the familiar bank of verbs, he gets stopped by even the slightest wall or jump. Dan, meanwhile, can only run and jump, blasting through some areas like a pinball champ. He can give Ben the odd lift, but most of the time when the pair are separated, it's only so they can find a way to come back together again through the kind of lateral thinking that went out of style at the turn of the millennium. The pixel-art style scales beautifully up to 4K, however, and the minimum spec GPU is 14 years old. It seems built with integrated graphics in mind, the sort of thing you can throw on a laptop after work for a chuckle as you decompress.

And yes, there are a lot of chuckles. Genuinely funny games are pretty rare, and this is the first to really earn that accolade since Amanita Design's *Chuchel,* back at the beginning of 2019. There's a very dry strain of humor on display here, however, as Ben and Dan face getting older and explain the idea of feelings to an ancient computer, that's lightened by some wonderfully puerile lines, swearing, penis jokes, social media in-jokes, and a few references to the authors' British childhoods that may go over many heads.

Lair of the Clockwork God is many things: Both an adventure and a platformer, it's also a bromance, a wry commentary on gaming as you get older, and something very funny indeed. There are points when it doesn't really work, and moments when you wonder if you're meant to be laughing but have missed a subtle joke, but otherwise it is a pleasure to play. If we were still in high school, we'd be quoting lines from it back and forth with our friends, and you can't praise it any more highly than that. **–IAN EVENDEN**

VERDICT **8**

Lair of the Clockwork God

ADVENTURE A fun tale with likeable characters; writing that will keep you laughing.

PLATFORMER Occasional control problems and points at which you feel lost by the wordplay.

RECOMMENDED SPECS 2.4GHz or more CPU; 4GB RAM; GeForce 8800.

$20, www.sizefivegames.com, ESRB: Not rated

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LAB NOTES

JOANNA NELIUS, HARDWARE STAFF WRITER

Not Goodbye, Just See-Ya-Later

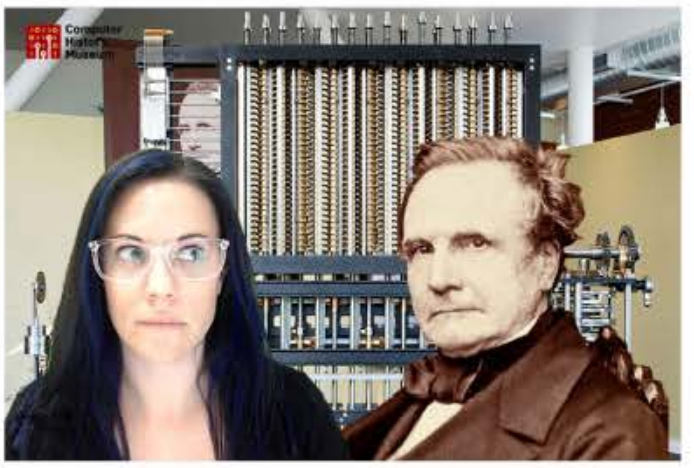
But don't forget to regularly dust your PC, for a change

I BELIEVE IN THINGS coming full circle, so my final "Lab Note" is about my dad. He graduated with a degree in computer science from Cal Poly Pomona, when PCs were heavy, all-in-one machines, with screens that looked like tiny TVs, and spent most of his life designing PC hardware. When the US entered a recession in 1990, it was the first of several times throughout his life that he was laid off from his job. But even when he was pushed out of the job market for good in 2009, he never lost his love for hardware—even when the technology outgrew his own knowledge and understanding.

I often imagine what he would say about things such as ray tracing, cloud gaming, liquid cooling, and SSDs that can fit in the front pocket of my skinny jeans. "You're telling me I don't need my own computer to run this game?" he'd say, as I handed him a Stadia controller. I wish I could have shared all the things I've written about over the last year and a half with him.

A few months ago, I visited the Computer History Museum, and my early memories of him came back hard. I wanted to hear his anecdotes of how he helped design some of the '70s and '80s hardware on display. I wanted to hear his lame nicknames for companies such as America "Offline" and Packard "Hell." I wanted to see his reaction when he saw a Gateway computer for the first time in 20 years.

But although my dad wasn't physically there, he was. He may not be famous for his contributions to computer technology's history, but he had a hand in it. I'm proud to be my father's daughter, and I plan to carry on his legacy in my own way.



Joanna's "selfie" with Charles Babbage from the Computer History Museum.

INDUSTRY INSIDER

There isn't a lot of competition in the tech world these days, is there? There are basically four motherboard vendors—five if you're on Intel—two graphics card manufacturers (one of which provides no high-end alternatives to the competition), and don't get me started on the processor situation. Flip-flop, back and forth, one's in charge for 10 years, then the other, and then the other again.

Don't get me wrong, even at *Maximum PC* these guys go on and on about how much choice you have, and how easy it is to build a bespoke system. And that is sort of true in the finer details: cables, cooling, cases, and, eugh, RGB. But let's face it, if you have a budget and a particular aim, the likelihood is your new rig's hardware—the beating heart stuff that really makes those processes go around—isn't going to be very different from a guy halfway around the world with the same ambition and the same funds. Competition is good, yet one of the most innovative industries out there lacks it almost entirely. What does that mean? A technological dark age, that's what.

Perhaps it's just an anomaly unique to this moment in time, and only because some companies are on the up today while others play catch-up tomorrow, but it really doesn't feel like there's much choice.

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Elgato Key Light Air

ARE YOU A STREAMER? Perhaps you are, perhaps you're not, but you need a new lamp, and want to convince your house guests that you're the kind of person who knows what "Twitch partnership" means. If that sounds like you, beware: Elgato is coming for your wallet.

Before we dive into the nitty-gritty of the Elgato Key Light Air, a little background for those unfamiliar with the filming process. LED ring lights for webcams and conventional softbox lighting are both used by online video performers, but they have drawbacks. For streamers and YouTubers, buying a setup of two or three standing softbox lights isn't necessarily expensive, but they guzzle electricity, take up a lot of space, and cause noticeable temperature build-up, particularly if you're committing to extended livestreams lasting hours.

Modern LED lighting can be effective, without the heat issue, but doesn't throw out as much light due to affordable design leading to fewer or cheaper individual LEDs. Looking toward the higher-quality, professional LED products sees a seriously sharp hike in price. The original Key Light cost close to $200, prohibitively expensive for many streamers getting their channels off the ground. Elgato has clearly heard the cries of Twitch's proletariat, as the new Key Light Air is far cheaper, but still firmly places itself in the "professional" arena.

At $130, the Air is slightly smaller than its predecessor, with a flat, square head that connects to a telescopic pole mount and weighted base. Unboxing and assembling the product took less than five minutes, no tools required, and setup using the Android app was equally swift. The Key Light Air comes with wireless tech that lets it hook into your home Wi-Fi network, so you can control it using either the app or the free desktop software. It's also compatible with Elgato's own Stream Deck control peripherals.

The control suite on offer is fairly bare-bones, enabling you to tweak the brightness up to an impressive 1,400 lumens, and also adjust the warmness of the light itself, from a soothing orange tone through to a stronger blue-white. It wasn't hard to find a configuration that illuminated our room well while also remaining gentle on the eyes. The app and desktop tool can also be used to turn the lights on and off remotely, and multiple Key Lights can be hooked into the same network for simultaneous control.

Anyone producing video content at home or in a small studio is likely to appreciate the simple, compact design. The footprint of the Key Light Air is just eight inches by eight inches, with a soft-edged quadrilateral plane of white plastic and concealed mesh that is lit via a ring of powerful LEDs around its edges. In this sense, it acts similarly to a softbox, ensuring that you aren't exposed to harsh direct light when you're trying to clean up grunts in *Halo: Reach* live on stream.

This setup means that the Air doesn't get anywhere close to as hot as most softbox lights. What might once have been the choking, sweltering atmosphere of a home studio can be replaced by a cool but warmly-lit space for recording; we left the Key Light Air at maximum brightness for hours, and while the rear of the unit itself did get quite warm, it certainly wasn't radiating heat to the rest of the room.

Ideally, if you want to get the best out the Key Light Air, you'll want two of them for a more even light distribution. That still adds up to $260, although we're confident in saying that it's better value than buying even one regular Key Light. For beginners, a single Key Light Air should do the trick. Bask in the glorious diffused light of your LEDs, while the softbox peasants sweat behind their keyboards. **–CG**

$130, http://elgato.com

EDITOR'S PICK

Zak Storey, Editor

FOLDING@HOME

A while back, before I left *Maximum PC,* I spoke about depression and anxiety. When I was growing up, I suffered from hypochondria, a fear of disease, among other things, and it effectively made me a shut-in for a year when I was 17 years old. In fact, it's been so prominent in my life that I can trace back panic attacks stemming from it to when I was six—perhaps ironically, the first was while I watched a documentary on the Spanish flu. Yet the older I've got, the more I've begun to realize that this wasn't actually a fear for my own wellbeing, but rather a fear of losing the people I love in my life.

Last summer, two of my grandparents, one from each side of my family, were diagnosed with cancer within a week of each other. My grandmother on my father's side was given 18 months to live, because she has late-stage leukemia. She has chemo to keep it under control, but it cripples her immune system in the process, making her high-risk to COVID-19. Because of that she's been advised to self-isolate for up to four months, potentially longer, with no contact from my family.

For me, finding a vaccine is more important than anything right now, because it means I might actually be able to see her again. Folding@home is a disease research project that's been set up by Stanford University. It takes spare computing power to simulate the process of protein folding and misfolding. This helps us understand disease biology, and gives us a better chance of identifying vaccines and antiviral medication quicker than traditional methods. I can tell you now, every machine I have is working flat out supporting this effort.

Free, https://foldingathome.org

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LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Killing OneDrive
> Reputable Free VPNs
> Intel vs. AMD

Win 10 and OneDrive

I frequently need to do a fresh install of Windows 10, but not frequently enough to remember that OneDrive will move data, pictures, and documents off my PC into the cloud. The result of this moving data off local storage may not be immediately apparent and, to compound matters, updates to that data go to OneDrive, too. I have searched the Internet for a fix, but find others just as confused. Somehow it's tied to "Libraries" preferences. To get the data back and unlink the PC is a relatively complicated process. I don't want my data only online, I don't want MS to rip off my data, and I don't want MS to hound me to set up a OneDrive account. Maybe, the real problem is I just don't understand OneDrive and why MS won't let you just opt out.

–O.B. Schooley

EDITOR, ZAK STOREY, RESPONDS: Good old OneDrive, being a pain as usual. It's a frustration of mine, too, to be honest. What's worse is the number of times I accidentally click the cloud icon when I'm trying to open the small icons bar on the bottom-right. That said, it's not too difficult to sort out, and when you've done it once, regardless of how many times you install Windows and sign in with your Microsoft account, you never have to worry again.

First, I recommend backing up all the files you want to save to an external hard drive or a USB stick. Then, right-click the OneDrive cloud icon in the notification area. Click "More," then hit "Settings," and finally, on the "Account" tab, click "Unlink this PC" followed by "Unlink account." This stops OneDrive syncing your files online. For more peace of mind, you can uninstall the entire app. Go to the "Start" menu, search "Add or remove programs," then under "Apps & Features," find "Microsoft OneDrive" and select "Uninstall." You need administrator privileges to do that, but then you'll be free of the OneDrive curse.

Video Editing Build

Hi, I am looking to build a new video/graphics editing rig and wanted to know if your March Gaming Powerhouse setup would do the trick? Thank you!

–Greg

EDITOR, ZAK STOREY, RESPONDS: This is actually something we're hoping to cover once the pandemic crisis is over. Depending on exactly what you're after, picking the right parts for a professional video editing machine can be tricky.

There's a few key criteria you need to check off when picking the parts. Gaming builds are fairly good when it comes to rendering, but they're geared toward clock speed and compatibility, rather than pure rendering performance, so not ideal in a professional environment. Aim to get as many cores as possible, with quad-channel memory and a good GPU to help accelerate graphics performance. Quad-channel memory is important because After Effects and programs like it eat up that extra bandwidth when rendering.

Depending on budget, look for components with long warranties and high reliability. For your CPU, choose either an AMD Threadripper or Intel Cascade Lake-X (depending on your preference), then follow it up with a high-end GPU. For memory, you'll probably want 32 or 64GB (four sticks) @ 3,200MHz. Combine that with a solid 1,000W-plus PSU for future expansion, and some good old air cooling, courtesy of Noctua, for added reliability. For storage, get a fairly sizable PCIe SSD for your boot drive, and back that up with 4–8TB of hard drive storage in a RAID configuration. Something similar to this: https://bit.ly/mpcbuild1. You could swap out to Intel with the Core i9-10920X, Asrock X299 Extreme4 motherboard, and Noctua NH-D15 for around the same cost if Team Blue floats your boat.

Free & Reliable VPN?

I try to read all of your issues, but I may have missed this: Is there a reputable and free VPN service that you would recommend? Thanks. **–Eric**

EDITOR, ZAK STOREY, RESPONDS: There's an old marketing saying that

↘ submit your questions to: comments@maximumpc.com

claims if you're not paying for the product, you are the product. And although the lines around that have certainly blurred over the years, with VPNs it is still true. There are a few free ones, but they usually come with a fairly minimal data cap, and much slower speeds than a standard network, so not ideal if you want to stream content from the other side of the planet, for instance.

You could try Hotspot Shield Free VPN—that's the best I've played with—which has the largest daily data cap, at 500MB. Or you could give Windscribe a go. This isn't one I've used (a colleague recommended it to me), but it does come with 10GB of data per month, so that's a plus.

Personally, I use ExpressVPN pretty much every day; it's insanely useful. I've got the year-long subscription, which equates to about $8.32 a month, so not exactly cheap, but I get good usage out of it. It also comes with a mobile app, and I've even got it hooked up to my router for maximum privacy across all my home devices as well.

Monitor Upgrade

Hi! As we both know, an unlabeled Dell 1680x1050 60Hz monitor is no match for an RTX 2060. I am looking to upgrade to something along the lines of a 1080p 144Hz monitor. I don't need anything super-gimmicky or gamery. I just want something reliable and presentable. My graphics card supports HDMI, DisplayPort, and DVI-D. Thanks for any help

–Alex Hill

EDITOR, ZAK STOREY, RESPONDS: I do love a good monitor upgrade and you've certainly got the card for the job, although it is a bit tricky going off so few specs. Usually, when we recommend monitors, knowing budget and screen size is important.

The big question is screen size. For 1080p, for pixel density alone, you're probably best off with a 24-inch panel; 27-inch gets a bit grainy, even compared to your (I'm assuming) 22-inch 1680x1050. That said, I'm a big fan of ViewSonic's range—on the whole, the build quality is really good, warranties impressive, and customer support good—so I'd recommend the ViewSonic VX2458CMHD. It's a curved 24-inch panel, and VA, so you've got nice crisp saturated colors. It also has that 144Hz refresh rate and a 1ms response time. It's about $160—a lot of tech for the price.

That said, the RTX 2060 is no slouch, so you could get away with a 27-inch 1440p screen. Most games, even AAA titles, will perform well above the 60fps mark with that, and you'll benefit from the extra screen real estate. If that sounds more intriguing, Samsung's C27JG56 is around $280. It's another curved VA panel, at 144Hz, and with a 4ms response. I've actually just recommended this model to a friend of mine.

Both panels have FreeSync as standard, so you'll likely be able to set up G-Sync, too. Check out our tutorial on page 52 for more information.

More Intel Please!

While I understand the magazine's preference for discussing builds based on AMD's processors, I'm writing to ask for a bit more Intel coverage. Why? While nowadays Intel isn't always the best performer, its long legacy ensures better compatibility, at least for now. I'd like to try running the Windows 10X emulator, or Google's new Fuchsia OS, both of which support Intel but not AMD CPUs.

So, what would I like to see? Just the occasional Intel build, so those of us planning to build on Intel can get your insights. And maybe one mid-level build at the end of the magazine, too? It needn't be updated each month. Thanks.

–Robert

EDITOR, ZAK STOREY, RESPONDS: This isn't the first time this has come up in our letters pages, and I understand where you're coming from. It was an Intel Core i5-2500K that got me into overclocking and then, eventually, this job, so I've absolutely got respect for the company. Almost all of my rigs are now AMD, based on the value and performance proposition they represent, but it's hard to deny just how much that little quad-core impacted my life.

Obviously, right now, things are a little difficult for us—with COVID-19 running rampant and impacting all our office and photography plans—but rest assured, once things return to normal, I'll work hard to ensure our content is suitably balanced between the two teams.

You may have noticed a few changes in this issue (outside of the page-cut)—red-hued reviews being one of them. As part of my new remit, I can tinker with the mag, try ideas out, and give things a refresh. Blueprints is an area I've wanted to adjust for some time, so this is something we'll follow up. As a general shoutout, if anyone has any ideas or something you'd like to see tweaked, we're always open to (constructive) criticism and suggestions. Email us at the address opposite, and we'll see what we can do.

[NOW ONLINE]

WFH? PROTECT YOURSELF FROM CYBER ATTACKERS

The concept of working from home and remote workforces has been around and in practice for a while now, but recent global events have changed the game entirely, with many governments urging citizens to dramatically increase social distancing measures. Indeed, COVID-19 has driven entire offices to close and whole companies to work from home, resulting in an unprecedented shift in the working landscape. Organizations are having to rapidly adapt, and a vital consideration is security, particularly given cyber attackers' propensity for opportunism in times of crisis.

Unfortunately, distressed global climates and times of uncertainty are prime times for hackers to launch attacks and we can already see targeted Coronavirus-themed phishing attacks in circulation. Therefore, it's imperative for organizations to implement business contingency plans that prioritize protecting remote workforces from attacks.

Read the full article: https://bit.ly/2J8xlFY

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$65
PSU	EVGA 400N1 400W	$35
Mobo	ASRock Fatal1ty B450 Gaming K4	$95
CPU	AMD Ryzen 5 2600	$125
GPU	Zotac Gaming GeForce GTX 1660 Super 6GB NEW	$220
RAM	16GB (2x 8GB) Team T-Force Vulcan Z @ 3,000MT/s NEW	$68
SSD	120GB Patriot Burst 2.5-inch SATA III NEW	$27
HDD	1TB Western Digital RE3 WD1002FBYS	$28
OS	Ubuntu Desktop Linux 18.04.3 LTS 64-bit	$15

Approximate Price: $678

A MODEST OVERALL PRICE DROP from our last issue, thanks to some small reductions here and there, means the Budget build is in a really good place right now, so we're not making too many changes here. A switch back to the 2x 8GB Team T-Force Vulcan Z memory kit was predicated by the GeiL Evo Potenza RAM no longer being on sale, and we also swapped back to a twin-fan GPU, specifically Zotac Gaming's standard 6GB model of the GTX 1660 Super, which happened to be 10 dollars cheaper than the previous Asus GPU. We also made the change from Adata to Patriot's Burst 2.5-inch SSD, sticking with the same amount of SATA storage (to keep our boot-ups nice and swift), but saving ourselves a few dollars, because the Adata SU650 is also no longer on sale at the time of writing. Patriot's drive is super-cheap and will do everything we need it to do here.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	$85
PSU	550W Corsair CV550 80+ Bronze NEW	$55
Mobo	ASRock Z390 Steel Legend NEW	$135
CPU	Intel Core i5-9600K NEW	$230
Cooler	Corsair A500 Dual Fan NEW	$100
GPU	MSI Radeon RX 5700 8GB NEW	$332
RAM	16GB (2x 8GB) Team T-Force Vulcan Z @ 3,000MT/s NEW	$68
SSD	500GB Seagate BarraCuda 510 M.2 PCIe SSD NEW	$80
HDD	1TB Western Digital RE3 WD1002FBYS	$27
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,212

THE PARTS THEY ARE A-CHANGIN'. Our Mid-Range build is making the shift over to Intel this month; we've been all over AMD for long enough. The Core i5-9600K we're using is a bit more expensive than the third-gen Ryzen chip it's replacing, but it also outperforms it on average by a small amount, and removes the need for an expensive X570 motherboard. So, we've got ASRock's Z390 Steel Legend coming in, too, and a powerful Corsair A500 air cooler, because we'll be missing the free Wraith cooler AMD provides. We're slightly increasing our available power with a new 550W CV PSU, also from Corsair. We're making the same memory change as in the Budget build, and swapping over to MSI for the GPU, because the XFX RX 5700 was no longer on sale. Lastly replacing the SSD with a cheaper, more suitable PCIe 3.0 drive, the BarraCuda 510 from Seagate, on sale for just $80.

UPGRADE OF THE MONTH

CORSAIR A500

If you're buying Ryzen, you can often keep your build costs down by rocking the included Wraith cooler. These AMD stock coolers are surprisingly effective, but if you're going for an Intel CPU, you need to invest in a proper cooler. In this case, we've opted for Corsair's high-performance A500 air cooler. A thick heatsink served by four pipes and equipped with two powerful maglev fans, the A500 is a straightforward cooling solution that works effectively and comes with PWM support for tweaking fan speeds. This being a Corsair product, it also comes with a sweet five-year warranty.

$100, http://corsair.com

© CORSAIR

SAVINGS GALORE! We stripped almost $100 from the Turbo build, thanks to a sale on ASRock's X399 Phantom Gaming 6 mobo, more price reductions on the second-gen Threadripper CPUs, and the also-reduced 1TB model of the Seagate BarraCuda 510 M.2 SSD we used in the Mid-Range build. It's an awesome selection, and we reinvested some of our spare budget in some funky RGB RAM, in the form of G.Skill's 32GB TridentZ RGB kit.

The EVGA RTX 2080 Super is no longer on sale at $690, so we also had to switch manufacturers on our GPU, keeping the price relatively low with the excellent-value 8GB Ventus model from MSI. We hadn't intended to swap out our power supply, but the G+ version of the 850W EVGA SuperNOVA leapt in price by over $20, so we switched over to its GA counterpart.

Lastly, we replaced the cooler. We wanted to stick with the triple-fan setup to ensure maximum cooling for our Threadripper 2950X, but our previous 360mm Fractal Design cooler had risen in price a tad much for our liking, so we found a replacement: the EVGA CLC 360, a powerful but minimalistic AIO cooler with three low-noise nano-bearing fans, and an RGB-lit pump block. EVGA's free Flow Control software enables you to tweak both the pump and fan speed with ease, and the combination bracket means it is fully compatible with TR4-socket Threadripper processors.

For more of our component recommendations, visit www.pcgamer.com/hardware/buying-guides/

INGREDIENTS

PART			PRICE
Case	NZXT H700i		$170
PSU	850W EVGA SuperNOVA 850 GA 80+ GOLD	NEW	$129
Mobo	ASRock X399 Phantom Gaming 6	NEW	$238
CPU	AMD Threadripper 2950X		$680
Cooler	EVGA CLC 360	NEW	$124
GPU	MSI GeForce RTX 2080 Super Ventus 8GB	NEW	$700
RAM	32GB (2x 16GB) G.Skill TridentZ RGB @ 3,600MT/s	NEW	$175
SSD	1TB Seagate BarraCuda 510 M.2 PCIe SSD	NEW	$150
HDD	2x 3TB Seagate BarraCuda Compute		$160
OS	Windows 10 Home 64-bit OEM		$100
Approximate Price:			**$2,626**

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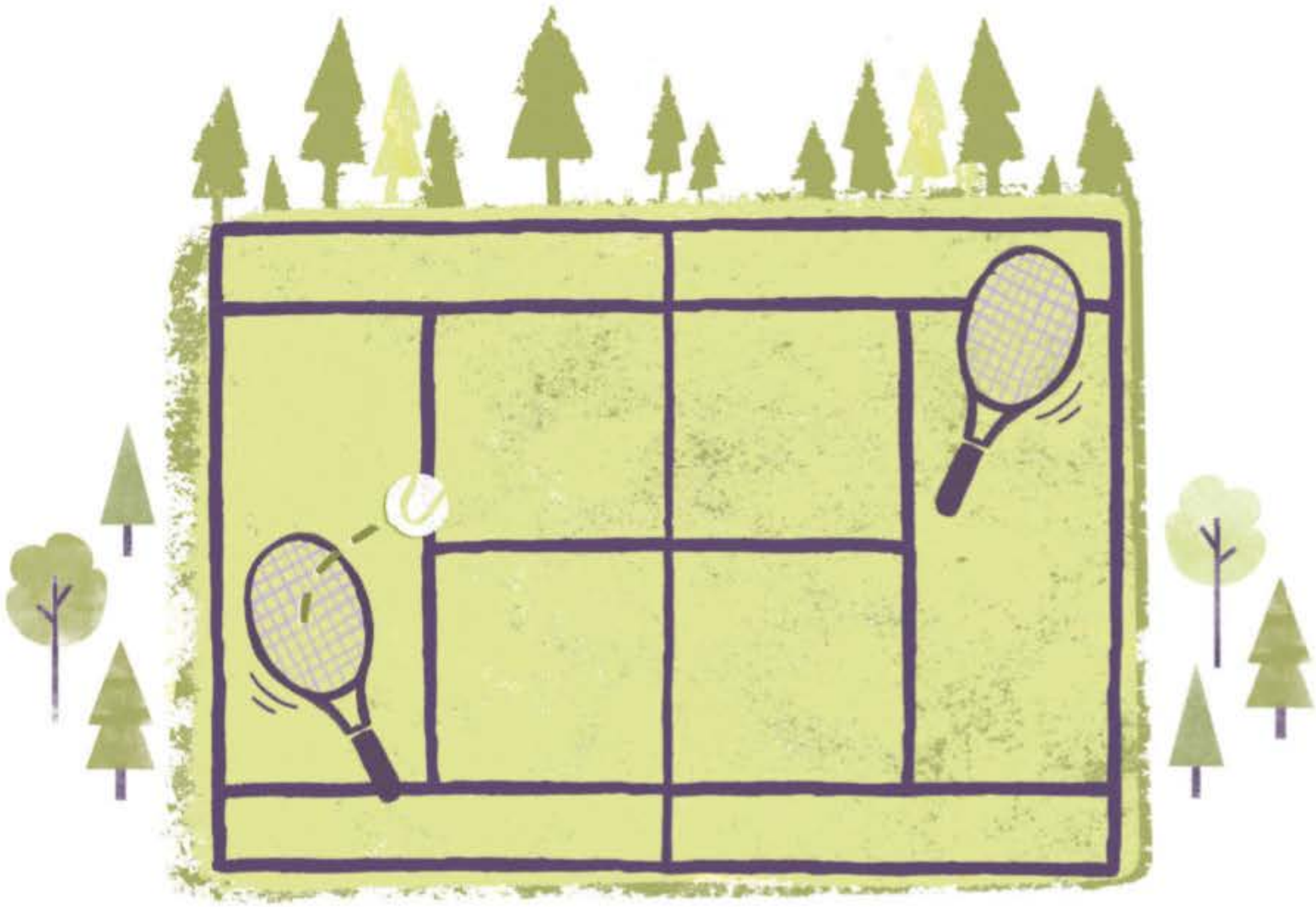

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